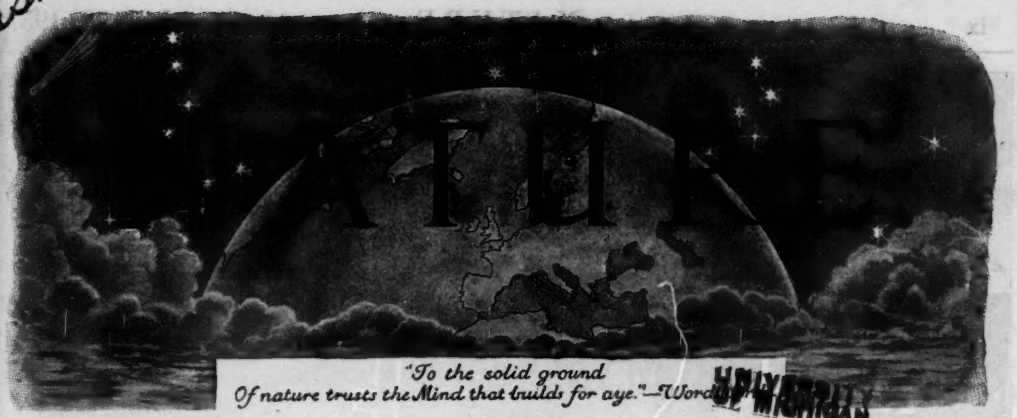

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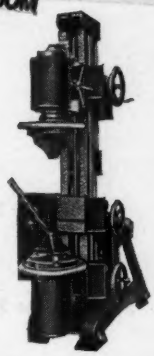

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NATURE

No. 4577 SATURDAY, JULY 20, 1957 Vol. 180

CONTENTS

Page

Science Buildings for Schools 103

Science and Values. By Prof. J. D. Bernal, F.R.S. 104

The Civil Service in Great Britain. By R. Brightman 105

English Place-names. By Prof. H. C. Darby, O.B.E. 106

Quantitative Neuroanatomy. By Prof. B. Delisle Burns 106

International Meteorology. By G. A. Bull 107

Keeping up with Low-Temperature Physics. By Dr. R. G. Chambers 107

Perception and Utilization of Light. By Dr. Robert Hill, F.R.S. 108

The Mullard Radio Astronomy Observatory, Cambridge. By M. Ryle, F.R.S. 110

The Red Algae (1906–56 and After). By Dr. Kathleen M. Drew 112

Solar Energy: a Challenge to the Future. By Dr. Harold Heywood 115

News and Views 119

Research on Metal Coatings 123

Vacuum Deposition of Metals 124

Chemical Engineering Education. By Prof. J. M. Coulson 125

Women in Industry 127

Early History of the Sauropsid Reptiles. By Dr. Edwin H. Colbert 128

Filter Feeding in Flamingoes. By Dr. L. Harrison Matthews, F.R.S. 129

The Site of the Neurohypophysial Osmoreceptors. By Prof. Yngve Zotterman 129

Mosaic Evolution in Hydroids. By Dr. J. E. Morton 130

How does the Ehrlich Ascites Tumour obtain its Energy for Growth? By A. Kemp and Prof. B. Mendel, F.R.S. . . . 131

Seismic Recordings of Atomic Explosions in Australia. By H. A. Doyle 132

A General Theory of Membrane Transport from Studies of Bacteria. By Dr. Peter Mitchell 134

Letters to the Editors:

The Units of Time and Length.—Dr. L. Essen . . 137

Delayed Signals in Ionospheric Forward-scatter Communication.—G. W. Luscombe 138

Ionospheric Studies by the Lunar Radar Technique.—B. C. Blevis 138

A Possible Auroral Enhancement of Infra-red Radiation emitted by Atmospheric Ozone.—Wallace B. Murcray 139

Effect of Ionizing Radiation on Solid Catalysts.—R. W. Clarke and E. J. Gibson 140

Molecular Weight Determination in Polyethylene Terephthalate.—I. M. Ward 141

Mechanism of Drying of Thick Porous Bodies during the Falling-Rate Period.—Prof. A. H. Nissan and W. G. Kaye 142

Para-Localization Energy (Free-Electron Molecular-Orbital) and Polarographic Half-Wave Potential of some Polynuclear Hydrocarbons.—Sadhan Basu and Rama Bhattacharya 143

Inactivation of Antihæmophilic Globulin by Thrombin.—Dr. C. Rizza and Dr. W. Walker 143

Insensitivity of Chicken Cholinesterase to Specific Inhibitors of True- and Pseudo-Enzyme.—Prof. W. Ferrari 144

Effect of Contrasted Planes of Nutrition on the Carcass Composition of the East African Dwarf Goat.—Dr. P. N. Wilson 145

Temperature Effects in Mammalian Nerve Regeneration.—Dr. H. J. Gamble 146

Lampbrush Chromosomes in Insects.—Dr. G. P. Sharma and Ram Parshad 147

New *s*-Triazine Herbicides.—Dr. H. Koopman, J. H. Uhlenbroek and J. Daams 147

A New Thiol in Legumes.—Dr. C. A. Price . . 148

Phosphorylase Inhibitor in Potato: Separation from Activator and Possible Relation to Chlorogenic Acid.—Dr. Sigmund Schwimmer 149

Germination of Oospores of *Phytophthora erythroseptica*.—Dr. Mary Gregg 150

Tsunamis.—J. Darbyshire and S. Ishiguro . . 150

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SCIENCE BUILDINGS FOR SCHOOLS

THE first full account of the work of the Industrial Fund for the Advancement of Scientific Education in Schools* appears when the Fund has virtually completed the active stage of its work. Almost all the schools to be visited have been seen and considered, and practically the whole of the £3,159,669 subscribed by 141 industrial firms has been committed. Building grants totalling £2,461,250, as well as £250,950 for apparatus, have been given or promised to 187 schools; and a further £110,300 for apparatus to another 143 schools. No grants have been made to voluntary aided schools, and the schools to which grants were made include 82 girls' schools. For these exactly the same criteria were applied, but with some exceptions girls' schools on the whole are as yet far behind the level of boys' schools.

The report of the Executive Committee of the Fund makes available a considerable amount of information relating to an aspect of education in Britain which has probably not previously been so closely surveyed, and this material and the conclusions reached are of especial interest at the moment for two reasons: first, on account of the renewed attention which the position of the voluntary schools, and particularly of the public schools, in the educational system of Britain has attracted; second, while there has been some discussion as to the extent to which the grammar schools are contributing to the supply of technologists, the report of Dr. Willis Jackson's Committee has emphasized the direct connexion between the supply of teachers for technical colleges and colleges of technology and the supply of science teachers in the schools. Evidence submitted to the latter committee indicated that of new staff entering the technical colleges in recent years, more than a quarter were teachers transferring from full-time service in schools, and a considerable proportion of these were graduates in mathematics and science.

Thus, while on one hand the work of the Industrial Fund should help to increase the supply of those entering on courses in science and technology at the universities and technical colleges, and ultimately the number of teachers in technical colleges as well as of teachers of science and mathematics in the schools, in the short run, by making science teaching in the schools more attractive, it could check a source of supply which is at present very welcome to the technical colleges. This, however, is not a source of supply on which the Willis Jackson Committee is disposed to rely. Apart from the desirability of teaching experience on the part of teaching staff in the technical colleges, it involves a severe loss to the schools at a time when they themselves are facing an alarming shortage of teachers of mathematics and science.

The Executive Committee of the Industrial Fund expresses the opinion in its report that, in the so-called 'independent' and 'direct grant' schools generally, as distinct from 'maintained' schools, the shortage of science teachers has been as yet a less critical problem than the lack of money for capital projects, though the comment is made that it is exceedingly difficult to find science teaching staff for the girls' schools. Moreover, the opportunities for women scientists in industry are not yet as clear as they should be, and the Executive Committee considers that industry as a whole must give more and urgent attention to this problem in future.

This problem apart, the report shows that there is a very strong wave of interest in science in the schools, which is still mounting, and the effect of which continues to spread. The Fund's activities have done much to accentuate this wave; but the tendency was marked well before the Fund was created. The Committee believes that the establishment of the Fund has set every school thinking, or thinking more intensely, on the national demand for scientists and technologists, and the means within its power to assist in meeting that demand. It believes that this effect has spread far outside the schools with which it has dealt, and that during the next few years many of the smaller schools could make a valuable contribution to Britain's scientific strength provided they get the assistance they merit and need.

In actual results the Executive Committee concludes that the requirements of the next five to ten years will be secured in the schools that have been assisted, and that the total teaching spaces for physics and chemistry and the area of teaching space per pupil more than thirteen years of age will both have been increased by about 50 per cent. Moreover, the improvement in facilities must have a marked effect on the general quality of output, and the money now committed will provide for an increase of 3,500–4,000 in boys and girls taking physics and chemistry at sixth-form level. In addition, while the Committee is satisfied as to the practicability of a mathematics and science sixth representing 60 per cent of the sixth, it also notes that in nearly all the independent and direct grant schools all boys are to-day taught science at some stage in their education.

These are encouraging observations which indicate that these schools are capable both of offering a real contribution to the nation's requirements for scientists and technologists and of furthering the general understanding of science and the scientific approach, which is no less needed. Here alone is sufficient ground for giving pause to attacks on the independent schools in the name of party political doctrine and in disregard of their contribution to Britain's strength. The Executive Committee of the Fund, moreover, in sizing up its problem, worked through qualified and experienced assessors who visited some 229 schools out of the 445 which completed the Committee's questionnaire, and much of the interest of the report

* Report on the Industrial Fund for the Advancement of Scientific Education in Schools. Pp. ii+35. (London: Industrial Fund for the Advancement of Scientific Education in Schools, 1957.)

lies in the considered views of these assessors which are set forth in an appendix.

Analysing the replies received, the assessors note that large schools produce a higher proportion of boys in the mathematics and science sixth forms, and that the most frequently mentioned obstacle to increasing the quantity and improving the quality of science teaching was lack of separate accommodation for the sixth form. This obstacle was reflected in the headmaster's decision to limit the numbers to match the capacity of the school laboratories; in the consequent tendency of parents and boys to decide that the boy should leave after studying physics and chemistry to the Ordinary level of the General Certificate of Education, or that in the sixth form the boy should pursue a course of studies for which the school is better equipped; and in greater difficulty in recruiting science staff. The assessors believe that by helping to increase the sixth form output, the Fund, although in operation concerned solely with buildings and apparatus, will produce more graduates from which the teaching profession can be recruited, and by improving the conditions for work will make science teaching attractive to more graduates. Furthermore, the provision of good preparation rooms and workshops is the first step to securing the skilled laboratory assistants which many schools need.

The assessors estimate that there may be in all the secondary schools in England and Wales some 30,000–35,000 boys and girls in the mathematics and science sixth forms, of whom some 20,000 are in the maintained schools. They suggest that while larger numbers taking science will increase the size of the pool from which scientists, technologists and science teachers may be recruited, the introduction to science of more girls and boys in the lower part of the school will provide some of the increase from the abler individuals who might otherwise have elected to follow a different course of study. Again, restriction of entry to the mathematics and science sixths to those who may, with fair confidence, be expected to have highly successful university careers, results in exclusion of boys and girls who, under the stimulus of lively teaching in good conditions, may well develop latent potentialities and become valuable recruits to industry whether or not they go on to universities.

Apart from the promising results already achieved, the report indicates that the Fund is being operated on lines very similar to those which Dr. Willis Jackson and his colleagues recommend for dealing with the supply of teachers for technical colleges. The hope of progress lies not so much in new or revolutionary measures as in the steady improvement of working conditions, so that they satisfy the legitimate needs of men and women of first-rate ability and high ideals. The report suggests that the contribution of the independent schools to the nation's needs for scientists and technologists is very far from being as negligible as it is sometimes represented to be, and that it would be only common prudence not merely to refrain from disturbing or interrupting that contribution, but rather to seek to augment by suitable measures the work which the Industrial Fund is doing to increase that contribution. Lastly, the success of the Executive Committee of the Fund in creating a mutual understanding and identity of interest between industry and the schools augurs well for response to the emphatic appeal of the Willis Jackson Report for co-operation between industry and the technical colleges. The very success of the Fund's work is, as the assessors rightly observe, a challenge to science teachers. It is no less a challenge to the nation generally. If already many of the ablest boys in the schools who were formerly channelled into the humanities are now indeed turning to science, it must not be left solely to the science masters to see that their ministrations do not produce narrow specialists but help those with whom they are in contact to make of science the core of a balanced education. They will require the support and encouragement of a public opinion, fully aware of what is required and alert to check any doctrinaire attempt to frustrate or hinder this invaluable contribution to one of the country's most pressing needs.

SCIENCE AND VALUES

Modern Science and Human Values

A Study in the History of Ideas. By Prof. Everett W. Hall. Pp. x+483. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1956.) 45*s*. net.

WE have had many books of late dealing with the relations of science and values in the age of the hydrogen bomb. The question of whether man's moral stature is capable of controlling the consequences of his intellectual achievements is becoming ever more acute. The answers given to it are for the most part didactic and unsatisfying. Here, in Prof. Hall's "Modern Science and Human Values", we have a somewhat different approach, based on the history of ideas, presented in a logical and philosophical framework. The general theme is that of the break-up of the unified Medieval picture of the universe in which fact and value are both determined by an omnipotent God as set out in His revelation. The emergence of natural science in the Renaissance opened the possibility of determining *facts* by experiment and calculation, but left *values* without solid support. It was some realization of this danger that urged the churches' resistance to the new knowledge, culminating in the trial of Galileo; but with their virtual failure the possibility of continuing to use divine ordinance to determine value also failed. For a while it seemed that the new science might succeed in the field of values also, and much of this book is taken up with the history of the rise and fall of a scientific ethic based on Galilean or Newtonian physics.

The work falls symmetrically into two parts, one on the history of science, and the other on values, and the progress of each is followed through five stages—Medieval, Renaissance, the Age of Reason (mainly during the eighteenth century), the Age of Romanticism (covering the nineteenth century), and the present age. There is a good deal of overlapping, so that Rousseau goes with Romanticism and Bentham with the Age of Reason, which makes the story

at times somewhat difficult to follow. There is also a curious eclecticism. Aristotle is fully treated but Plato is not mentioned, though there is much about the Cambridge platonists. Hobbes is treated as a central figure but Descartes never appears nor does Spinoza. Franklin and Priestley do not get any hearing amid a host of obscure eighteenth-century moralists. These absences show that Prof. Hall is concerned less with writing a comprehensive history than with illustrating an argument.

It is evident throughout that, as a good professor of philosophy, his concern is chiefly in the evolution of ideas about values, but the first section holds some interest for students of the history of science. Here there is no claim to uncover new material but rather, by a different arrangement of well-known facts, to bring out connexions hitherto missed. Particularly useful is his running together of economic theory with natural science. Aristotle's economics, with its disparagement of interest, was as much rejected in the Renaissance as his theory of motion. The central argument is that the attack on the theory of motion towards an end—the *telos* or accomplishment of purpose—denaturalized both science and ethics. The common-sense world disappeared and an abstract mechanical-mathematical causality took its place. One interesting suggestion put forward, that I have not seen elsewhere, is that Newton's definition of quantity of matter, "as arising from its density and its bulk conjointly", is not so much a circular argument as an attempt to assess the invariant in Boyle's experiments on the compression of gases, and is thus the forerunner of conservation theories. The account of present-day science stops with Einstein's theories, which are made to serve somewhat incongruously as an introduction to marginal economics.

The second section, on human values, is more for historians of philosophy and ethics. Hobbes's denial, in his "Leviathan", of all objective value save as vested by common surrender into the hands of an arbitrary state is shown as the starting point of the attempt to make an ethic without God. Here Prof. Hall draws the distinction between voluntarist ethics —'good' is what I, or the Bible, or the king, say is good—and naturalist ethics, which is independent of any human command. The great advance of modern times, he claims, is the discovery that statements of fact and of value are of different kinds. As we read on we hope to find out what values really are, but we are doomed to disappointment. Prof. Hall's history ends with the logical positivists who claim that statements about value are meaningless because unverifiable. He does not himself believe this, but what he believes is not history but philosophy, so that the answer will be in another book.

J. D. BERNAL

THE CIVIL SERVICE IN GREAT BRITAIN

Civil Service or Bureaucracy?

By Dr. E. N. Gladden. Pp. 224. (London: Staples Press, Ltd., 1956.) 21*s*. net.

IN this, his third book on the Civil Service, Dr. Gladden gives a concise review of the structure of the Civil Service to-day, its evolution, conditions of service, methods of selection, training and promotion, the methods of control and of joint consultation and other factors which determine its morale, before continuing the discussion of the problem of adapting the Service to the changing needs of to-day on which he embarked a dozen years ago in "The Civil Service: its Problems and Future". Their discussion occupies the five chapters which comprise the second part of the book; but the first part, while adding little to the contribution of various other volumes on this theme during the past ten years, contains some shrewd criticism and makes several sound comments. Moreover, Dr. Gladden's book includes an annotated select bibliography, covering the more important Parliamentary papers, and also an index.

For that reason alone, Dr. Gladden's book is likely to be more useful than most other recent books on the subject in supplementing the report of the Priestley Commission for those seeking to gain some understanding of the function of the British Civil Service to-day and its relation to the national welfare. To provoke such public understanding is one of Dr. Gladden's main purposes in writing this book. He reiterates again and again the need for such understanding and for a change in the public mind towards the Service. Protesting firmly against ill-informed criticism of the Civil Service, he points out that, in misrepresenting public administration to the people, the Press is obstructing the advance in effectiveness of popular government. Whatever improvements may be possible either in the Civil Service itself, or in the organization of Government, their effectiveness depends on an enlightened citizenship, well informed on political questions and capable of discussing practical problems without excessive emphasis upon emotional and sentimental factors.

That condition has not yet been served, nor will it be easily or cheaply secured. Whether Dr. Gladden will be more successful than previous writers in reaching those quarters where it is most essential for public understanding to be increased is perhaps doubtful, but his book is a very readable effort to that end and it gives clear warning of the dangers that attend neglect. As he rightly concludes, a Civil Service adequate to present needs will emerge only on the wings of a more liberal understanding.

Dr. Gladden's other main purpose is with the administrative aspect of the Civil Service, which he examines critically, and he offers again, but rather more diffidently, his suggestion of a personnel organization board to watch over the staffing patterns of the various departments and to control the flow of transfers according to needs so as to encourage a general level of opportunity throughout the Service. The idea behind the suggestion is to encourage and reward genuine initiative by raising the level of staff management and efficiency. Since Dr. Gladden first made this suggestion in 1945, the system of promotion pools has greatly facilitated this type of adjustment, but while there may still be opportunity for an impartial board such as he suggests, the greater need is to encourage and strengthen the professional outlook in the Civil Service. Some of Dr. Gladden's views, in the chapter in which he advocates formation of a professional council for the Civil Service, are open to challenge—government scientists will scarcely allow to pass without comment the remark that their function is research, not administration—but he rightly argues for official recognition that the study of public administration is a desirable activity on the part of any Civil servant, and that the outstanding lesson of the Crichel Down incident is the threat offered to public freedom by

the inefficient self-centred official rather than any deficiency revealed in the constitutional system.

More important, however, than Dr. Gladden's particular proposals for reform is the way in which, firmly and clearly, he points to weaknesses in the existing system—to lack of vision, to short-sighted economies, whether dictated by internal tradition or misguided external pressure and criticism. On the principles of promotion he writes with sense, shattering the notion that we are compelled to choose between seniority and merit, for example. He sees clearly the danger of bureaucracy, but above all his book indicates the great contribution to the public welfare which could be made by a Civil Service staffed and trained to meet the new demands, given the support of a public opinion, critical, alert and informed and alive to the central fact, to which the last report of the Civil Service Commissioners testifies, that public respect and adequate remuneration even more than past traditions are the essential factors if we are to recruit for the Civil Service in Britain men and women of the high ability and integrity its work demands.

R. Brightman

ENGLISH PLACE-NAMES

English Place-Name Elements

By A. H. Smith. Part 1: Introduction, Bibliography, The Elements A–IW, Maps. Pp. lvi+306. Part 2: The Elements Jafn–Ytri, Index and Maps. (English Place-Name Society, Vols. 25 and 26.) (Cambridge: At the University Press, 1956.) 35*s*. net each volume.

THE English Place-Name Society was founded in 1922, and two years later there appeared a slim volume of some 70 pages written by Sir Allen Mawer and called "The Chief Elements used in English Place-Names". It was intended, as its preface said, to provide a companion to the county volumes that were yet to appear, and it has proved an invaluable guide. Since that time, the Society has published twenty-four volumes dealing with nineteen counties, and other volumes are in active preparation. In view of the vast amount of material already assembled, the time seemed appropriate for "a new and more extensive study", and the present two volumes are the result.

They present a very striking testimony to the achievement of the Society over the past thirty years or so. Such work as this can be accomplished only as the result of the most patient and meticulous scholarship guided by acute and critical judgment. Primarily, the elucidation of place-names makes a contribution to the study of language, but this is only a part of its interest. The evidence of place-names constitutes a major source for the history of early Britain, that is, for a period for which other sources are slender in amount and difficult to interpret; and the ramifications of this interest concern the archæologist and the historical geographer. These present volumes combine the expertize of the philologists with an appreciation of the problems that confront the student of early society and early landscape in Britain.

The entries are arranged in the form of a dictionary, and the space devoted to each varies from a single line to many pages; a number of entries are, in fact, in the nature of long articles. Those dealing with *by*, *ing*, *ham*, *tun*, *thorp* and *wic* are of particular interest, and it is clear that the use and meaning of many names were far more complicated than could have been envisaged thirty years ago. Moreover, a complicating factor is that language is far from being static, and that names change their meaning with changing circumstances. Thus *burna* was the ancient word for stream, but it was often transferred to the names of settlements nearby and it fell into disuse as a living word for stream, to be replaced by *broc*. Similarly, the application of *tun* to enclosure, then to farmstead and so to village meant that *tun* came "to denote much the same kind of settlement as *ham* formerly did", and so *ham* disappeared as a living element in place-name formation. The result is that *ham* names are most frequently encountered in the south-east and in East Anglia, while *tun* or *ton* names are more characteristic of the Midlands. It is through such difficulties as this that Prof. A. H. Smith threads his way with care. The entries are abundantly illustrated with examples; cross-references are frequent, and full account is taken of earlier views on this or that point.

The volumes are accompanied by a number of maps which indicate, among other things, the distribution of Celtic and of Scandinavian place-names. The last is particularly welcome. Isaac Taylor's map of 1863, so often used in the past, has at last been superseded. The work is happily dedicated to Prof. Eilert Ekwall of the University of Lund in Sweden. He is a vice-president of the Society, and his many contributions to the study of English names, particularly his "Dictionary", have placed us all in his debt.

The volumes provide not only a stock-taking of the work so far accomplished but also a guide and stimulus for what is to come. The work of the English Place-Name Society constitutes one of the most important projects of scholarship, on a national scale, that are afoot. It not only illumines the dark places of our history but also furnishes a constant source of interest for those who travel about the countryside or look at its maps. The Society, and not least Prof. Smith himself, are to be warmly congratulated on this *tour de force*.

H. C. Darby

QUANTITATIVE NEUROANATOMY

The Organization of the Cerebral Cortex

By Dr. D. A. Sholl. Pp. xvi+125. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1956.) 18*s*. net.

Studies on the Cerebral Cortex (Limbic Structures)

By Santiago Ramón y Cajal. (Translated from the Spanish by Lisbeth M. Kraft.) Pp. xi+179. (London: Lloyd-Luke (Medical Books), Ltd., 1955.) 27*s*. 6*d*. net.

THERE is, at present, good reason for claiming that less is known about the cerebral cortex than any other mammalian organ; at the same time, the demand for an organized body of structural and functional knowledge had increased rapidly during the past thirty years. The neurologist, the psychiatrist and the electroencephalographer are continually asking the neurophysiologist questions about mammalian behaviour which he cannot yet answer. Frequently, because the limitations of neurophysiology are not fully comprehended, hypothesis is confused with established fact, and elaborate structures of explanation are built upon what was never more than scientific speculation.

For this reason I feel that Dr. Sholl's excellent book will interest a wide variety of readers. This work provides a clearly stated review of established facts and hypotheses concerning both the structure and function of the cerebral cortex. In this monograph, Dr. Sholl stresses the limitations of neurohistology, and provides a summary of his own contributions to this field. The latter are, in the writer's opinion, of considerably more importance than their factual content, since they seem to mark the end of an era of descriptive histology and the beginning of a quantitative study of structure.

An English translation, by Lisbeth M. Kraft, of Cajal's papers on the mammalian olfactory cortex is also now available, under the title "Studies on the Cerebral Cortex". Cajal's anatomical studies of the limbic system certainly represent the most comprehensive and precise account available of what is now called the limbic system. Cajal was the master of qualitative micro-anatomy and there are few neurophysiologists who have not leaned heavily upon his works. But while descriptive histology of central nuclei and tracts has proved invaluable to an understanding of the more primitive functions of the nervous system, history shows that it has contributed little to our present understanding of the cerebral cortex.

It is not possible at present to link up such scanty knowledge as we have of cortical function with the available micro-anatomical data, and in fact Dr. Sholl is forced through no fault of his own to present his review in two independent sections, dealing separately with structural and functional information. It is only within recent years that physiological study of the cerebral cortex has become quantitative in nature; the recent development of quantitative micro-anatomy may well prove the essential step toward an understanding of normal and abnormal cerebral function.

B. Delisle Burns

INTERNATIONAL METEOROLOGY

Scientific Proceedings of the International Association of Meteorology, Rome, September 1954

(International Union of Geodesy and Geophysics, Tenth General Assembly.) (Publication AIM No. 10/c.) Pp. xiii+594. (London: Butterworths Scientific Publications, 1956.) 80*s*.

THIS publication is the official report of meetings held as part of the tenth general assembly of the International Union of Geodesy and Geophysics. While most of the one hundred and four papers stated to have been read are apparently reported in full, some are merely given in title and many in a short abstract. Against some of these nominally reported papers there is stated the periodical in which a full account was destined to appear.

The meetings, apart from the presidential address by Prof. K. R. Ramanathan, were divided into eighteen colloquia on specific subjects, ranging from cloud physics to numerical prediction of the pressure distribution. The papers relating to the distribution and transport of ozone in the atmosphere seemed to me to be the best. The presidential address is a notable survey of this subject right up to date at the time of delivery. The outlines of a picture of the transport of ozone from the region 20–30 km. high where it is produced by photochemical action on oxygen to the lower atmosphere are beginning to take shape and ozone to be used as a tracer to reveal the circulation.

Dr. Schumann of South Africa put forward a strong plea for the formulation, by a world conference, of an international co-operative plan to guide meteorological research for twenty years or more. This proposal met with strong opposition from the audience of freedom-loving research workers. On a more practical level he demanded much greater co-ordination, simplicity, and uniformity in the publication of meteorological information, rightly pointing out the loss of time involved in searching for data at present. He should be given strong support in this by the World Meteorological Organization, one of the functions of which is to co-ordinate publication arrangements between meteorological services. Perhaps unfortunately, he seems to have attempted to urge too much and, moreover, to have gone out of his way to attack that document beloved of so many meteorologists, the synoptic chart.

Other subjects than those mentioned which were treated very fully at the meeting were radiation and the mechanics of the general circulation. The meteorology of the lowest layers of the atmosphere at normal breathing-level was the most conspicuous absentee. Although there has been at least one instance of a new idea of basic importance being first put forward at a meeting of the International Association of Meteorology, it seems unlikely that the event will often be repeated. Authors are unlikely to wait three or more years for such congresses to publish their new ideas. The most useful functions of congresses seem to be personal intercourse of research workers from all over the world and the preparation and later publication of surveys of the current state of knowledge.

G. A. Bull

KEEPING UP WITH LOW-TEMPERATURE PHYSICS

Progress in Low Temperature Physics

Edited by Prof. C. J. Gorter. Vol. 2. Pp. xi+480. (Series in Physics.) (Amsterdam: North-Holland Publishing Company; New York: Interscience Publishers, Inc., 1957.) 42 guilders; 84*s*.

WITHIN the past year or two, the closely related topics of low-temperature physics and solid-state physics have been exhaustively reviewed: we have had three volumes of "Advances in Solid State Physics", the four relevant volumes of the new "Handbuch der Physik", and now here is the second volume of Prof. Gorter's "Progress in Low Temperature Physics". Even before the appearance of this last, the point had been reached where at least two, and often three or four, lengthy and up-to-date review articles were available on most of the major topics in these fields, and it is a measure of Prof. Gorter's skill as an editor that he has succeeded in choosing for his second volume a number of topics which have not recently been treated elsewhere. Perhaps inevitably, the result has a somewhat heterogeneous appearance. As Prof. Gorter himself remarked in his preface to the previous volume, low-temperature physics nowadays constitutes a 'transverse section' of paragraphs from many different chapters of physics, and it is debatable whether a useful purpose is served by bringing to-

gether in one volume a miscellaneous collection of such paragraphs, out of their natural contexts and having little in common but a particular range of temperatures.

In fact, however, some unity has been given to the present series by concentrating largely on one of the classic problems of this field: the behaviour of helium itself. In the present volume, as in its predecessor, almost half the space is devoted to the properties of helium at low temperatures in the solid, liquid and gaseous phases. Van Dijk and Durieux review the evidence leading to the Leyden 1955 vapour-pressure scale, and also discuss briefly the American 1955 scale. It is lamentable that there should be at present two 'rival' temperature scales, and unfortunate that Keller's criticisms of the Leyden scale appeared too recently to be considered in this review. Other articles discuss the properties of liquid helium in slits, in films and below 1° K., and of solid helium. Lastly, there is a lengthy discussion by de Boer of 'solid-like' models of liquid helium, which to some extent complements the more realistic but less rigorous approach described by Feynman in the previous volume.

In contrast to this liberal treatment of helium, the other classic problem of low-temperature physics, superconductivity, is represented here by only one short article on superconducting alloys and compounds. Indeed, in the two volumes together, five times as many pages are devoted to the properties of helium as to superconductivity. This presumably reflects editorial policy: it need scarcely be said that it in no way reflects the relative amount of progress to be reported in the two fields.

The remaining seven articles cover a miscellany of topics, including conduction in metals, properties of semiconductors, the de Haas–van Alphen effect, paramagnetic relaxation, the rare earths, nuclear orientation, and lattice specific heats, and moreover they differ rather widely in level of presentation. In view of this, it is difficult to recommend the volume unreservedly to a general audience. Those working specifically on the properties of helium, however, will no doubt find it a useful companion to the previous volume.

R. G. Chambers

PERCEPTION AND UTILIZATION OF LIGHT

Radiation Biology

Edited by Alexander Hollaender, with the co-operation of Sterling B. Hendricks. Vol. 3: Visible and Near-Visible Light. (Prepared under the Auspices of the Committee on Radiation Biology, Division of Biology and Agriculture, National Research Council —National Academy of Sciences, Washington, D.C.) Pp. viii+765. (London: McGraw-Hill Publishing Company, Ltd., 1956.) 75*s*.

THE subject of this volume is of special significance because the transformations of energy with many essential components of living organisms are 'tuned' to radiation in the visible and near visible spectrum. The variety of problems under investigation which belong to photobiology is very large indeed, and it might seem too much to expect that all aspects could be contained in a single volume. Yet, as may be seen from what follows here, the subject is covered in the fifteen chapters remarkably well.

The first three chapters deal with physical problems; first a discussion of energy exchanges involving atoms and molecules, where the use of potential diagrams is developed in relation to the theory of absolute reaction rates. This is followed by a most valuable exposition of the physics of light absorption by molecules; two important classes of biological pigments, carotenoid (polyene) and tetrapyrrolic pigments (chlorin and porphin), are dealt with. This chapter gives an account of some dramatic achievements in this field. Thirdly, there is a longer section on the practical physics of the radiant energy, which is most ably presented. The next four sections deal with photosynthesis: the quantum requirement, the mechanism of photosynthesis, the spectroscopy of the pigments and the formation of chlorophyll in the plant. The discussion on the mechanism of photosynthesis where the physical, physiological, and biochemical approaches are combined is well documented and of a distinctly individual character. The part played by light in the nitrogen cycle of plant growth is discussed separately. I think the climax is reached in Chapters 9 and 10, which give with masterly authority accounts of phototropism and photoperiodism. The writing is well sustained in the following two chapters on seed germination and the relation of light to the physiology of the cell. The next two chapters are concerned with eyes. Although the account of electrical phenomena in vision contains a wealth of information, I was sorry not to find more about human colour vision, more about the biochemistry of visual pigments and just a little about quantum requirements, for aspects analogous to these have whole sections devoted to them in photosynthesis. The account of invertebrate photoreceptors is of a quality which whets the appetite for more (actually, we are promised this by the contributors next year); this chapter, together with the second, on excitation of polylenes and porphyrins, are perhaps largely responsible for the unique character of the book. The last contribution, on the old-established subject somewhat strangely known as 'photodynamic action', contains recent material which is fundamental both to photobiology and to radiobiology as a whole. On the use of the various symbols for defining absorption and extinction coefficients, information is scanty and it is not collected together in any one section. We are given good descriptions of the natural pigments and their absorption spectra but the reader may find difficulties with the quantitative data. The usual convention has been to employ common logarithms in extinction coefficients and natural logarithms in absorption coefficients. The curves given for the chlorophylls have the ordinates labelled absorption but the values are in common logarithms: thus the reader may be compelled to consult other literature unnecessarily. I would have welcomed some selected tables of extinction coefficients for several of the pigments and feel tempted to appeal to future editors concerned with spectroscopic data to allow the publication of data in tabular form rather than, or in addition to, the curves from which it is both difficult and tiresome to get values for different wavelengths.

The editor and his distinguished colleagues are to be congratulated on their skill in producing this volume, which is a valuable addition to literature on general biology. It should appeal to a wide range of advanced students. Though the contributions were mainly completed in 1951 they are an indispensable guide to current research.

Robert Hill

Valency and Molecular Structure

By E. Cartmell and Dr. G. W. A. Fowles. Pp. xi+256. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1956.) 32*s*. 6*d*.

THE authors say in the preface that inorganic chemistry is unpopular in Britain because it includes so many facts, a failing which it shares with organic chemistry, and that it can be made more attractive by discussing the facts in the light of crystal chemistry and valency theory. The results from both these fields are subject to periodical revision, and this has occurred in parts of the text of the book. On p. 169 the bond angle and interplanar angle in hydrogen peroxide are given as 97° and 94° but the figure on the next page shows them as 101·5° and 106°, and on pp. 107 and 168, the bond angle is given as 104½°. This makes the argument for a tetrahedral arrangement less convincing. The statement on p. 169 that steam is about 10 per cent associated is obviously wrong. There is a danger that a student taught too narrowly on such lines will memorize a fund of information which will very soon be obsolete.

The book opens with an account of Bohr's theory in which the quantizing relation is due not to Bohr as stated, but to W. Wilson, and it is an accelerated and not simply a moving charge which radiates energy. The introduction to the wave theory is good, but the solutions to the equations can only be stated. Students of chemistry need to know the main results before they can be expected to understand a detailed treatment, but some of the results are given very briefly; two pages suffice for the treatment of the hydrogen molecule by the valency-bond method. The sketch of the molecular orbital method is good and the chapter on directed valency and hybridization should convey some understanding of the principles. The diagrams are particularly clear and helpful.

The third part, dealing with some fields of application, is good, and if the reader does not understand parts of it the references given will enable him to look up the original literature, which in many cases he will find even less intelligible. The book on the whole gives a readable and useful summary of the subjects of which it treats and will be helpful and interesting to students of chemistry.

J. R. PARTINGTON

Quantitative Chemical Analysis

By Cumming and Kay. Eleventh edition revised by Dr. Robert Alexander Chalmers. Pp. xvi+540. (Edinburgh and London: Oliver and Boyd, Ltd., 1956.) 30*s*. net.

PHYSICO-CHEMICAL theories and methods of analysis have been widely extended over recent years, making analytical chemistry a complex subject comprising such individual topics as radioactivity, polarography, chromatography, emission spectroscopy and flame photometry. In order to cover each subject adequately, individual text-books would be necessary for each branch of analysis, but for the convenience of university students one book dealing with some aspects of all methods of analysis is useful. It is to such a class of text-book that this revised edition of "Quantitative Chemical Analysis" belongs.

The subject-matter of the book is divided into the usual sections—the use and care of apparatus, volumetric, gravimetric and gas analyses. Each individual analysis is well described, both in its introductory note and in its practical application. Sections rewritten include a brief, but by no means complete, account of the underlying theories of precipitation, and the chapter relating to colorimetry. Considerable improvement on previous editions can be detected throughout this latter chapter, both in the general classification of the methods and in the inclusion of some of the more modern colorimetric methods of analysis at present in use. It is, however, disappointing to note that the precision of the methods described is not noted. The inclusion of the short section on ethylene diamine tetra-acetic acid, the new versatile reagent for volumetric and colorimetric analysis, is worthy of mention. The final chapter of the book summarizes some of the modern physico-chemical methods of analysis. Another innovation worthy of mention is the inclusion of additional specialized reading matter, appropriately placed at the ends of certain chapters. This is particularly useful to the student who wishes to extend his knowledge beyond the scope of this book. The revised edition of "Quantitative Chemical Analysis" still continues to be of use to the student, but is not sufficiently detailed for the research or advanced worker.

K. FIELD

The Principles of Therapeutics

By Prof. J. Harold Burn. Pp. ix+278. (Oxford: Blackwell Scientific Publications, 1957.) 27*s*. 6*d*. net.

THE Department of Pharmacology in Oxford is a very active one, and a great spate of publications comes from it. Prof. J. H. Burn's lectures to medical students in Oxford have now been published in a short and readable book. It starts with a quotation from Chaucer and a short section on the picturesque origins of materia medica leading to a discussion of the position of drugs to-day. This is followed by about ten chapters dealing with acetylcholine and adrenaline and noradrenaline and histamine and the substances which modify their actions. This is much the best part of the book. It gives a stimulating account of the striking way in which pharmacologists have been able to make fundamental contributions to physiological knowledge. Oxford has played a leading part in these advances and these chapters are richly illustrated with data obtained there.

The rest of the book contains a summary of those other parts of pharmacology which the medical student must learn, enlivened by accounts of how some recent discoveries have been made. For example, the story of ergot is well told; and the work which led to the introduction of thiouracil into medicine is described in detail. The effects of alcohol are discussed at some length and the problems of sterilization receive original treatment.

When Prof. Burn went to Oxford he undertook to give instruction in "Pharmacology and Principles of Therapeutics". He has taken the second part of this title for the name of his book, but this choice may be misleading. These must have been stimulating lectures, but they deal with pharmacology with little more than the usual references to the application of pharmacological knowledge in therapeutics. It has become well-nigh impossible for one man to be an authority on both pharmacology and therapeutics, and the subjects are best taught by two men working together. This book calls for a complementary volume written by a clinician.

J. H. GADDUM

THE MULLARD RADIO ASTRONOMY OBSERVATORY, CAMBRIDGE

By M. RYLE, F.R.S.

THE expansion of the research programme in radio astronomy, which was started in 1946 at the Cavendish Laboratory, has involved the use of increasingly large areas of land. With the completion of the four-aerial radio telescope in 1953 it became clear that further developments on the present site were impracticable, and plans were made for the establishment of a new Observatory at which the work might be extended.

A satisfactory site was eventually found some five miles south-west of Cambridge, and work on the construction of the new Observatory was started in June 1956. This development has been made possible by a generous benefaction from Mullard, Ltd., and by a grant from the Department of Scientific and Industrial Research.

The new Observatory, which will be known as the Mullard Radio Astronomy Observatory, will remain part of the Cavendish Laboratory, and will eventually include all the radio astronomical work at Cambridge; for the next two years, however, the existing site will be retained so that the programmes now being carried out with the present instruments may be finished. The buildings for the new Observatory are now complete, and the installation of two of the new instruments is well under way. A ceremony has been arranged for July 25, at which Sir Edward Appleton will formally open the Observatory.

The site consists of a triangular piece of level ground covering about 180 acres, which will allow the use of aerial systems extending up to 3,500 ft. in an east–west direction, and up to 2,000 ft. in a north–south direction. In addition to the laboratory building which will house the greater part of the electronic apparatus and offices, other buildings are available to provide workshop and storage facilities.

The aerial systems, as in all radio astronomical work, represent the major item of expenditure, and also involve the most difficult problems of design. In the present installation it was decided not to proceed with the construction of a single large general-purpose type of instrument, such as those at Jodrell Bank, Leyden, Harvard and Bonn. Instead, plans have been made for the construction of a number of specialized instruments, each designed to investigate a particular type of problem. In this way it seems possible to build more powerful instruments at considerably smaller cost.

Of the two instruments now being built, one is intended for the study of radio stars, and the other for the investigation of the continuous galactic radiation at a long wave-length.

The further study of radio stars involves two basic requirements: the instrument must have a high angular resolution so that adjacent sources may be distinguished individually, and it must possess a large 'collecting area' in order to detect faint sources without an inconveniently long integration time.

With conventional methods these requirements are conflicting: the use of a short wave-length to improve the resolution involves greater detection problems, since the flux from the source and the sensitivity of present types of receiver both decrease with decreasing wave-length. The use of a longer wave-length allows aerials of larger physical size to be constructed economically since the permissible errors in the 'figuring' and the spacing of the wires in the reflecting surface may be increased; it may, however, still remain difficult to achieve a sufficient resolving power. A wave-length of 1·7 m. was chosen as the best compromise for the radio star instrument, and both the resolving power and the collecting area are to be increased by a new technique which is best described as 'aperture synthesis'.

The number of radio stars which can be resolved is determined by the primary reception pattern of the system, but the use of interference fringes within the primary pattern has been found valuable in distinguishing between the radio stars and irregular features in the background radiation, and in discriminating between classes of radio stars having different 'surface brightness'. It also allows improved positional accuracy. The new radio-star instrument has therefore been designed to operate primarily as an interferometer.

The other instrument now being built also makes use of the principle of aperture synthesis to produce what is effectively a 'pencil beam' system; it is designed to study the distribution of the intensity of the galactic background radiation at a wave-length of 7·9 m. Observations with high resolution have been made at shorter wave-lengths, but they have been limited by lack of sensitivity to regions comparatively close to the galactic equator. Observations at high galactic latitudes at longer wave-lengths have revealed many unexpected features, but the detail available has been restricted by the poor resolving power.

The new instrument is intended to provide a large resolving power with sufficient sensitivity to investigate these high-latitude regions, besides obtaining observations near the equator to compare with those at shorter wave-lengths.

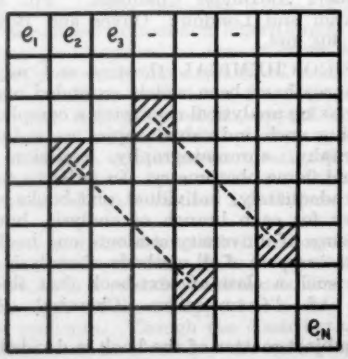

Fig. 1. Diagram to illustrate the principles of 'aperture synthesis'

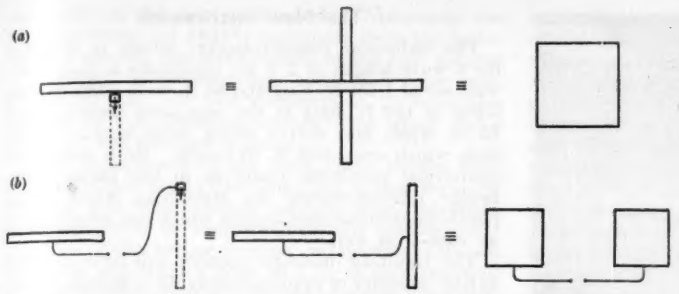

Fig. 2. The synthesis of (*a*) a single aperture and (*b*) an interferometer by the moving aerial method. The Mills cross and its interferometric counterpart are shown for comparison

Aperture Synthesis

Consider the formation of the reception pattern of a normal aerial such as a mirror or an array of elementary dipoles connected by feeders. Such an aerial aperture may be regarded as being made up of a number of small elements as shown in Fig. 1, in which electromotive forces of complex amplitude $e_1 e_2 \ldots e_n \ldots$ are excited by the incident wave.

The magnitude $|E|$ of the output voltage is then given by:

$$|E|^2 = [\underset{N}{\Sigma} e_n][\underset{N}{\Sigma} e_m]^*$$
$$= \Sigma|e_n|^2 + \Sigma e_n e_m^*$$
$$= \Sigma|e_n|^2 + \Sigma|e_n|\,|e_m| \cos \varphi_{nm}$$

where φ_{nm} is the phase difference between e_n and e_m. The reception pattern of the aerial arises from the variation of $|E|^2$ as the relative phases of the electromotive forces alter with the direction of the incident wave-front.

If the source of radiation remains constant, the same result can be achieved by using only two elementary aerials and arranging that they are moved to take up, in succession, all the positions of the elements in the real aerial; the addition of the terms $|e_n|^2$ and $|e_n|\,|e_m| \cos \varphi_{nm}$ obtained in this way will be exactly equivalent to the use of the real aerial. This principle will be referred to as 'aperture synthesis'; it can be used to provide a resolving power equivalent to that of a very large aerial without requiring the corresponding complications of construction and operation.

The measurement of $\Sigma|e_n|^2$ involves simply the measurement of the power received by one of the elementary aerials. The cross-product terms $|e_n|\,|e_m| \cos \varphi_{nm}$ may be measured by connecting the two elementary aerials to a phase-switching receiver of the type described by Ryle[1]. If the length of one of the connecting feeders is increased by a quarter of a wavelength, then the quantity $|e_n|\,|e_m| \sin \varphi_{nm}$ may also be determined; both quantities are required for the summation of the cross-product terms with modified values of φ_{nm}. If the phases are altered in such a way as to introduce a progressive phase variation across the aperture, then the summation will yield a reception pattern which is the same as that given by rotating the real aerial. The reception pattern can thus be moved to different directions simply by calculation and without the need for new measurements.

It can be seen from Fig. 1 that many of the arrangements of the elementary aerials are identical; apart from requirements of sensitivity, it is therefore unnecessary to repeat observations in which the relative positions of the two elementary aerials are the same, providing that the amplitude measured for each relative position is scaled by a factor proportional to the number of times that that particular spacing and orientation occur. In order to synthesize a line aperture, for example, a triangular grading of the measured terms is required; a square aperture requires a two-dimensional grading in the form of a pyramid.

If an aperture is split into N elements, corresponding to the use of two movable aerials each of which has an area $1/N$th of that of the synthesized aerial, then it can be shown that it is necessary to measure $2N$ cross-product terms. Once these terms have been measured it is possible, purely by computation, to deduce what response the whole aerial would give in any direction within the reception pattern of one of the elementary aerials. Since the reception pattern of the whole aerial has a solid angle $1/N$th of that of the elementary aerials, a real aerial would have to be set in N separate directions to obtain the same information. With a given integration time, the time taken to scan the sky with the aerial synthesis method is therefore of the same order as that with a large aperture.

There is no reason why the two elementary aerials should be of the same size; in the present instruments two-dimensional motion of the elementary aerials has been avoided by using a small aerial which moves along a north–south line in conjunction with a long fixed aerial which is mounted east–west and which occupies a whole row of the element positions. While this method involves the construction of an aerial of larger area, a long narrow aperture running east–west

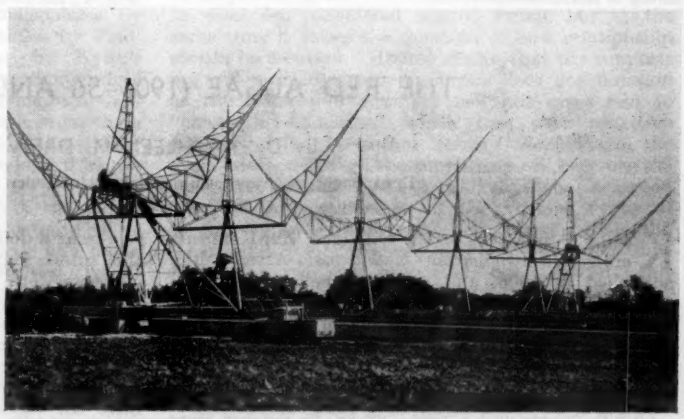

Fig. 3. The moving aerial and railway tracks of the radio-star interferometer. The fixed aerial is of similar construction but is 1,450 ft. in length

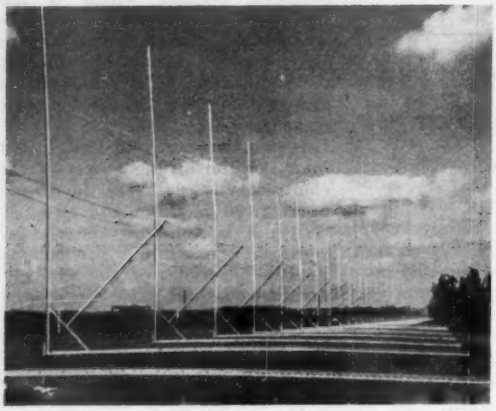

Fig. 4. Part of the fixed aerial of the 'pencil beam' system

can be built very much more economically than a square aperture of comparable size, since it may be supported at many points on the ground, and rotation about the long axis can be achieved without the need for high structures. In addition to simplifying the mathematical processes of record-synthesis, this method decreases the total time of observation in large systems, where scanning in right ascension must make use of the Earth's rotation. The method has been used at Cambridge in a smaller pencil beam instrument built by Blythe.

It can be seen from Fig. 2 (*a*) that the system described is equivalent to the cross-aerial of Mills[2], but it has two important practical advantages: first, it is not necessary to phase the elements of the north–south aperture, since scanning in declination is accomplished in the process of computation; and secondly, it becomes practicable to construct systems of considerably greater sensitivity, since for equivalence the area of the north–south arm of the cross must equal the area covered by the moving aerial.

The synthesis of an interferometer may be achieved in a similar way by taking measurements with a pair of elementary aerials arranged to occupy, successively, all positions in two separated apertures. The practical system which has been adopted is shown in Fig. 2 (*b*); a long fixed aerial running east–west has again been used in conjunction with a smaller aerial moving along a north–south line.

The New Instruments

The radio-star interferometer, which is designed for a wave-length of 1·7 m., comprises a fixed east–west aerial 1,450 ft. long and 65 ft. wide; the moving aerial is 190 ft. long in the east–west direction and 65 ft. wide, and moves along north–south railway lines which are 1,000 ft. in length. Both aerials are cylindrical parabolas made as in the earlier Cambridge interferometer[3] by stretching wires across parabolic tubular steel frames which can rotate about an east–west axis.

The resulting envelope pattern will have a width to half intensity of approximately 25 × 35 min. of arc, and this will contain an interference pattern in right ascension having a lobe separation of about 8 min. of arc. The equivalent 'collecting area' of the instrument will be approximately 190,000 sq. ft., which will provide considerably greater sensitivity than any previous radio-star instrument. The main structure of the moving aerial and the railway tracks are shown in Fig. 3; the construction of the long fixed aerial, which is now being assembled, is similar.

The 'pencil beam' system for galactic study is designed for a wave-length of 7·9 m., and uses a fixed east–west aerial 3,200 ft. long and a moving aerial which has a range of 1,700 ft. Each aerial is in the form of a corner reflector having an aperture of 40 ft. The reception pattern of the instrument will be approximately 1° × 1° to half intensity, and the equivalent collecting area is approximately 200,000 sq. ft. Part of the fixed aerial is shown in Fig. 4.

The operation of both instruments will involve a large amount of mathematical computation to synthesize the recorded data. The co-operation of the University Mathematical Laboratory has been sought, and methods have already been developed for the synthesis on EDSAC of the records obtained with the earlier instrument of Blythe; similar methods will be employed for the new instruments.

In addition to the two large radio telescopes which are now being built, the area of level ground which is available will make possible many investigations employing simpler systems of high resolving power; it is hoped in this way to extend a number of lines of work which have been investigated at the present site.

[1] Ryle, M., *Proc. Roy. Soc.*, A, **211**, 351 (1952).
[2] Mills, B. Y., and Little, A. G., *Austral. J. Phys.*, **6**, 272 (1953).
[3] Ryle, M., and Hewish, A., *Mem. Roy. Astro. Soc.*, **67**, 97 (1955).

THE RED ALGAE (1906–56 AND AFTER)

By Dr. KATHLEEN M. DREW

Department of Cryptogamic Botany, University of Manchester

KYLIN'S[1] first work on the red algae "Zur Kenntnis einiger schwedischen *Chantransia*-Arten" was published in 1906, and now, at the end of 1956, seven years after his death, the long-awaited publication of his last work "Die Gattungen der Rhodophyceen"* is welcomed by algologists and doubtless by other botanists as well. The fifty years covered by the period between the appearance of these two works represent a definite period of advance in the study of this interesting group of plants, and, although his interests were by no means confined to the Rhodophyta, Kylin was one of the main contributors to this progress. The results of previously published researches form a substantial part of this new book; but even those fortunate enough to possess some or all of the earlier papers will find it of great help to have the material gathered together in the appropriate order in one volume. This had been done

* C.W.K. Gleerups Förlag, Lund. 125 Sw. Kr., or cloth bound 135 Sw. Kr.

previously in the now unobtainable "Anatomie der Rhodophyceen" of 1937[3]; but apart from the introductory section, the arrangement in the new volume is primarily on a taxonomic basis, and more convenient to use. In this arrangement, it resembles volumes of the "Pflanzenfamilien", for which series this book was planned originally.

While comparison of the book under review with the first edition of the Rhodophyceae in that series by Schmitz and Hauptfleisch[3] shows what advances have been made by comparatively few workers since the date of the earlier volume, comparison between this book and Kylin's book of 1937 is disappointing in showing little change. Instead of a new approach, there is little alteration of those parts of the older text which are used again, although publications calling for a modification of previously expressed views had appeared, for example, Svedelius's[4] classical work on *Galaxaura* and all this implied. Among less important statements, the assertion that the haploid number of chromosomes in haplobionts is 8–10 and in diplobionts 20, and that a spireme exists in prophase of nuclear division may be cited as examples.

Kylin made considerable contributions to our knowledge of the cytology, physiology, anatomy, morphology, taxonomy and classification of the Rhodophyta; but in this book, as its name implies, it is primarily the bearing of his anatomical and developmental studies on taxonomy and classification that is the main theme. These researches, published in papers in 1923[5], 1928[6] and 1930[7], together with others such as those on the Gigartinales[8], Rhodymeniales[9] and the Delesseriaceae[10], led to rearrangements and refinements of the earlier systems of classification, mainly those of Schmitz, and resulted in a more natural grouping of families. Schmitz, on the basis of the development of the carposporophyte, had recognized the Nemalionales, Gigartinales, Rhodymeniales and Cryptonemiales at the end of the last century, and following the same line Oltmanns[11] separated the Ceramiales from the Rhodymeniales. At that time nothing was known of the sequence of somatic and nuclear phases of the life-history. Nevertheless these five orders are still accepted, and to them Kylin[5] added a sixth, the Gelidiales, for the single family the Gelidiaceae. He removed this family from the Nemalionales on the assumption (not yet proved or disproved) that the presence of tetraspores implies a diphasic nuclear cycle. Since then other orders have been erected, the Sphaerococcales, by Sjostedt[12], the Bonnemaisoniales by J. and G. Feldmann[13], the Acrochaetiales by Feldmann[14] and also the Nemastomales by Kylin[15] himself; but in this final work Kylin acknowledges the five orders of his predecessors and his own Gelidiales. While at the time he erected this order there may have been some justification for it, it is not clear why he retained it in the light of modern work on other Nemalionales.

From his work on the development of the carposporophyte, Kylin came to hold very definite views about the auxiliary cells of the Florideae and made the presence or absence of what he termed typical auxiliary cells, as well as their position, a basis for delimiting the orders, as reference to p. 81 will show. There are students of the red algae, including the veteran scientist Svedelius[16], who do not entirely support Kylin's views about the auxiliary cell, but who nevertheless would probably accept his major groupings in the absence of a better system. The establishment of such a better system should be one of the aims of the next generation of workers, each related assemblage being given monographic treatment, and as many characters of diagnostic value as possible found. The Nemalionales would repay such treatment for it appears to be a heterogeneous assemblage, including both very simple and highly elaborate types, whether they be considered from the point of view of vegetative construction or reproduction. Further, Fritsch[17] (p. 656) pointed out some years ago that the basis of distinction used by Kylin for separating the Cryptonemiales and Gigartinales, namely, whether the auxiliary cell is a normal intercalary cell or in an accessory branch, is of minor importance. While agreeing completely with Fritsch, it should be pointed out that this is a character which does not appear to hold in all cases. Various families of these orders should be subjected to further scrutiny to throw light on the value of these diagnostic characters given by Kylin.

A recent study on one of these families, the Kallymeniaceae*, is a start in this direction. Investigated from the taxonomic point of view, there are well-illustrated accounts of the female reproductive branch-systems and the stages in the development of the carposporophyte for species of *Kallymenia*, *Pugetia* and *Callophyllis*. Shorter accounts are included for species of *Polycoelia*, *Erthrophyllum* and *Glaphyrymenia*. Some of the observations suggest the need for a revision of certain accepted features about these structures, for example, that there may not be constancy in the cells which fuse to transfer the fertilization nucleus, for example, in *Kallymenia reniformis*, where the carpogonium is said to fuse with either the supporting-cell or the first cell of the carpogonial branch. Similarly in *Callophyllis*, the trichogyne and supporting-cell are said to fuse in one species and the carpogonium and first cell of the carpogonial branch in another. Similar variation is reported in critical stages in the development of the carposporophyte previously thought to be constant, the most revolutionary being that in *Pugetia fragilissima*. Norris states that "It seems likely that the supporting-cell of some functional carpogonial branches might produce a gonimoblast instead of (or as well as) connecting filaments". Unfortunately there is no information about the early movements of the fusion nucleus, information difficult to obtain, but of the highest importance. This work is of service in emphasizing the need of detailed critical studies in what are considered related forms, but at the same time it raises the question of how relationship should be assessed. Having shown that the supporting cell in *Kallymenia reniformis* does not function as the generative auxiliary cell but gives rise to "connecting-filaments" which fuse with nutritive auxiliary cells, the author leaves *Callophyllis* in the same family although the supporting-cell becomes the generative auxiliary cell. Thereby, the accepted view of the significance of the various types of carposporophytes is brought into question. On the other hand, major rearrangements are best left until alterations can be supported by thorough and detailed investigations of the development and structure of the vegetative parts of the thallus, the reproductive organs and the carposporophyte.

Throughout Kylin's book, useful keys are provided, first to the orders, then within orders to families, and

* Morphological Studies on the Kallymeniaceae, by R. E. Norris. (Univ. Calif. Pub. Bot., 1957. 28 (5): 251–334.) 1.75 dollars.

within families to genera. In contrast to the list of diagnostic characters of the various orders, some of which are surprisingly brief, for example, those of the Cryptonemiales and Gigartinales, the general introductory sections for each family are extensive, and will be of great value for reference. After a statement of the main diagnostic characters, each of these sections contains accounts of the vegetative and reproductive organs. In the main, these are taken from "Anatomie der Rhodophyceen". The generic descriptions contain the essential information and indicate the approximate number of species with their geographical distribution. It is stated (p. 33) that 558 genera (some of which are new) and 3,740 species are mentioned. Many genera contain a small number of species, and of the fifty-five families listed at least six contain a single genus each with a single species.

It is well known that much remains to be done in elucidating both vegetative structure and reproduction in the Bangiophycidae, and with only imperfect knowledge classification of these algae is bound to be makeshift to a certain degree. However, the classification given by Kylin is a modification of Skuja's[18] and seems to result in a more natural grouping of genera.

The book is well laid out, has a clear and detailed list of contents which enables the reader to reach the required section quickly and easily, good indexes and list of literature. It is plentifully illustrated, although the figures (many of which have appeared before) are not as well printed as in the "Anatomie der Rhodophyceen". There are typographical slips, many of which have been listed, but considering the circumstances in which the book has come into being, these should be excused. It is unfortunate that its price is so high.

It is not easy to put oneself back into the situation as it was in 1944 when the manuscript of this book existed already, and to view it from that position, as one should do, when evaluating it. Before his death, Kylin had realized the difficulty of incorporating new material into a book which had already been written for some time, and had therefore planned to add a supplement. This task fell to his wife, Elsa Kylin, who carried out the work most faithfully and has thereby made a most valuable addition to the book. This brings the book up to date, and although the reader has to assess the implication of the new work on statements in the main body of the work for himself, this is not difficult to do since it is conveniently arranged. Algologists all over the world will be very grateful to Elsa Kylin not only for this section but also for the immense and successfully accomplished task of seeing this work through the press.

What is the outlook for the next half-century? While predictions of what will be done are clearly unsafe, it is possible to indicate some of the interesting aspects of the study of these plants which deserve further attention. First, in what other groups of plants can one see quite so clearly and extensively the development of elaborate thalli from the basic unit, the branched heterotrichous filament? This is a fascinating morphological study of the first order. Differentiation into main axes and laterals can be seen leading on to differentiation of laterals into ones of limited and unlimited growth, with correlation of the growth of the laterals in the more advanced types.

Secondly, while the basic story of reproduction in the Florideae, characterized by non-motile sexual and asexual reproductive cells and the distinctive female cell the carpogonium, has been known for roughly a century, no comprehensive comparative consideration of the 'female reproductive branch' has yet been undertaken. In attempting this, an investigation of new forms as well as re-investigation of old types would probably be desirable.

Related to this is the parallel study of the carposporophyte, the structure which develops from the zygote, and the chief function of which is to produce spores. One of the unique features of this phase is the transfer of either the fusion nucleus itself or one of its derivatives, to one or more specialized cells of the gametophyte, the generative auxiliary cells. The present state of our knowledge is one of bewildering variety and it will remain in this condition, or get worse, as long as we are without a satisfactory interpretation of the carposporophyte. Investigations have been made mainly with a view to taxonomy, since features in the development of this phase and of the auxiliary cells have been considered, and quite rightly, to be of importance for classification. Now a comparative survey, from the point of view of the lines of its development, organization and specialization, is much needed. Here again, fresh investigations and reinvestigations would doubtless be needed.

Interpretation of the life-histories of the Florideae has always proved difficult. While a parallel might be considered to exist between the carposporophyte of these algae and the capsule of a moss plant, there is still no instance in the red algae in which reduction division has been shown to take place in the carposporangium, although such is often assumed in textbooks. So while the moss life-history can be considered to fall within the Hofmeisterian concept of 'alternation of generations', no known life-history of a red alga can be so considered. This is one of the facts about life-histories of these algae which makes fresh concepts, that is, ones other than those put forward in "Die Gattungen der Rhodophyceen", imperative, as are necessary, in fact, for all algal phyla. Apart from the presence of the carposporophyte is the additional fact that it is haploid in some, for example, *Nemalion*, and diploid in the majority, for example, *Polysiphonia*. Correlated with this is the absence of a tetrasporophyte present in most red algae in the former type. So in the *Nemalion*-type there are two dissimilar somatic phases, the gametophyte and the carposporophyte, both of which are haploid. In the *Polysiphonia*-type there are also two somatic phases, corresponding to those in *Nemalion*, but with important differences. The one somatic phase, represented by the gametophyte only in *Nemalion*, is represented by both the gametophyte and the tetrasporophyte in *Polysiphonia*, the former being haploid and the latter diploid. In *Nemalion*, there is only one nuclear phase, which is haploid, there being only a diploid state of the nucleus and no diploid phase or stage as in *Polysiphonia* where the diploid nuclear phase could be considered to dominate. The other interesting point about the *Polysiphonia*-type of life-history is that the two nuclear and two somatic phases do not coincide, a single somatic phase being haploid or diploid according to its position in the obligatory sequence of events and, although so unlike morphologically, the carposporophyte and tetrasporophyte are both diploid.

Although for most botanists there are two types of life-history in the Florideae, those of *Nemalion* and *Polysiphonia*, there exist many others, some

much better known than others, and continued investigations of these will certainly lead to a modification of current views on life-histories. Additional proof of all life-histories by means of culture and cytological investigations is needed. Complete experimental proof of the *Polysiphonia*-type exists for a very few species, and it is conceivable that an attempt to uphold the accepted *Nemalion*-type by culture would fail.

There is therefore room for much interesting work and scope for the formulation and testing of new ideas in this group of algae. Kylin's last work provides a well-equipped base camp from which to set forth.

[1] Kylin, H., "Botan. Studier tillägn. F. K. Kjellman" (Uppsala, 1906).
[2] Kylin, H., "Anatomie der Rhodophyceen". "Handb. d. Pflanzenanatomie". Hrsg. von K. Linsbauer, Berlin (1937).
[3] Schmitz, F., and Hauptfleisch, P., "Rhodophyceae", in Engler u. Prantl's "Die natürlichen Pflanzenfamilien", **1**, 2 (Leipzig, 1897).
[4] Svedelius, N., *Nova Acta Soc. Sci. Ups.*, Ser. 4, **13**, 1 (Uppsala, 1942).
[5] Kylin, H., *Svenska Vet. Akad. Handl.*, **63**, No. 11 (Stockholm, 1923).
[6] Kylin, H., *Lunds Univ. Årsskrift*, N.F. Avd., 2, **24**, No. 4 (Lund, 1928).
[7] Kylin, H., *Lunds Univ. Årsskrift*, N.F. Avd. 2, **26**, No. 6 (Lund, 1930).
[8] Kylin, H., *Lunds Univ. Årsskrift.*, N.F. Avd. 2, **28**, No. 8 (Lund, 1932).
[9] Kylin, H., *Lunds Univ. Årsskrift*, N.F. Avd. 2, **27**, No. 11 (Lund, 1931).
[10] Kylin, H., *Lunds Univ. Årsskrift*, N.F. Avd. 2, **20**, No. 6 (Lund, 1924).
[11] Oltmanns, F., "Morphologie und Biologie der Algen", **1–2** (Jena, 1904–5).
[12] Sjöstedt, L. G., *Lunds Univ. Årsskrift*, N.F. Avd. 2, **22** (Lund, 1926).
[13] Feldmann, J. and G., *Ann. Sc. Nat. Bot.*, Ser. XI, **3**, 75 (1942).
[14] Feldmann, J., Proc. First Int. Seaw. Sympos. Edinburgh, 1952, Inst. Seaw. Res. Inveresk, 11 (1953).
[15] Kylin, H., *Lunds Univ. Årsskrift*, N.F. Avd. 2, **21**, No. 9 (Lund, 1925).
[16] Svedelius, N., *Blumea*, Suppl. **2**, 72 (Leyden, 1942).
[17] Fritsch, F. E., "The Structure and Reproduction of the Algae" **2** (Cambridge, 1945).
[18] Skuja, H., *Acta Hort. Bot., Univ. Latvic.*, **11–12**, 23 (Riga, 1939).

SOLAR ENERGY: A CHALLENGE TO THE FUTURE*

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EARLY civilizations paid homage to the Sun as the giver of all life; and indeed it is now realized that the radiation emitted by the Sun is the ultimate source of all our heat and industrial power, except for that derived from nuclear origin. The sources of energy that are most easily utilized have been stored by a process of natural concentration. Coal and oil formed by the metamorphosis of living matter represent a concentration in time; water-power derived from elevated lakes caused by the deposition of water evaporated from the oceans represents a concentration in space. Facilities for water-power are, however, limited to suitable regions, while world reserves of coal and oil are decreasing and will eventually reach a stage of serious shortage. Radiation from the Sun, however, is received continuously, and could be used in localities with suitable climates to reduce the importation of expensive fuels and to improve the amenities of undeveloped arid areas.

Direct solar radiation as received at the Earth's surface is relatively low in intensity, though the total magnitude far exceeds that of all other energy resources, for in fourteen days the Earth receives radiation equivalent in heating value to the whole of the estimated world coal reserves. The problems involved in the artificial collection of radiation are mainly caused by this relatively low intensity, the intermittent nature and variable direction of the source. The radiation intensity external to the Earth's atmosphere is remarkably constant, varying only by $\pm$ 1·5 per cent of the mean value of 2 cal./cm.^{2}/min., or 430 B.Th.U./ft.^{2}/hr. or 1,350 watts/m.^{2}. There is also a variation of $\pm$ 3·5 per cent of the mean value due to changes in the distance from the Sun to the Earth. These variations are insignificant compared with the variation in transmission through the Earth's atmosphere, due to cloud, haze and dust. Even with clear skies, there is still considerable variation due to the relative thickness of atmosphere through which the rays must pass, termed the air mass. The air mass depends on the time of day, season of the year and the latitude of the place considered.

The spectral distribution of the solar radiation indicates that the surface temperature of the Sun is nearly 6,000° C. The maximum intensity is at a wave-length corresponding to green light, and the energy is about equally divided between the visible light range and the infra-red range up to 3 microns wave-length. The atmosphere absorbs nearly all the ultra-violet wave-length and certain bands in the infra-red are almost completely eliminated by water vapour and carbon dioxide.

Economic applications of solar energy are limited to localities in which there is a high proportion of clear sunshine during the winter as well as during the summer. The most favourable areas are mainly situated between latitudes 40° and 20° north and south of the equator; excessive humidity in the tropical equatorial zone is a handicap.

The serious study of solar energy utilization began a hundred years ago, and quite elaborate equipment was built during the early years of the twentieth century. Güntner (Austria, 1854–73) experimented with mirror systems and solar boilers; Mouchot (France, 1860–80) constructed a solar boiler and steam engine, and in 1878 operated an ammonia absorption refrigerator to produce ice by solar radiation. Pifre (France, 1878) constructed an improved mirror system and solar boiler, using the engine for driving a printing press at the Exposition Universelle in Paris. Bessemer (England, 1868) built a solar furnace which will be described later. Ericsson (United States, 1864–88) built mirror systems combined with boilers or hot-air engines, and also developed a number of instruments to measure solar radiation, obtaining a very accurate value for the solar constant, the rate of incidence outside the Earth's atmosphere. Adams (England, 1876) constructed a solar cooker for use in India; Harding (England, 1883) installed a solar distiller for drinking-water supply in Chile, which covered an area of

* Substance of a Friday Evening Discourse delivered at the Royal Institution on May 24.

51,000 sq. ft. and operated successfully for twenty years. Other experimenters in the United States built various types of solar engines, and the final stage in this sequence of developments was designed by Shuman (United States) in collaboration with Sir Charles Boys. This was a mirror system with steam boiler, engine and water pump erected on the bank of the Nile at Meadi, near Cairo, in 1912. The total effective area of the concentrating mirrors was nearly 14,000 sq. ft.

Most of the inventors during this early development period used expensive mirror systems to generate steam and hence mechanical power; but fuel was then cheap and plentiful, and although the experiments had some degree of success they were abandoned after a few years. Interest in the subject revived in 1945, due to the increased cost of fuel with the realization that supplies will become more difficult in the future, and also the desire to extend some of the benefits of industrial communities to undeveloped countries which lack natural supplies of coal and oil. Active research was initiated in the United States, but many other countries are now engaged in schemes which have application to their particular localities.

The immediate scope has changed from power development to the collection of solar radiation as low-grade heat, that is, heat at a temperature below the normal boiling point of water. This can be accomplished with relatively simple equipment, and with a collecting efficiency of the order of 60 per cent, whereas there are still many problems to be solved in the generation of solar power, which for inescapable thermodynamic reasons can only have an efficiency of the order 5–10 per cent. This low-grade heat may be used for domestic hot-water supply, house heating at night, distillation to provide drinking water from salt water and eventually for air conditioning and refrigeration, which would be one of the most beneficial applications in tropical countries.

Although this lecture is restricted to a consideration of artificial collectors of solar energy, it should be mentioned that the natural process of photosynthesis by the living plant, itself the greatest and most important user of solar energy, has been fully investigated as regards improvement in the efficiency of carbon fixation, that is, the effectiveness with which the incident sunlight is utilized. This fixation efficiency is very low for natural conditions of growth because so much of the solar radiation falls upon unproductive parts of the plants or on the spaces between the plants; it is less than 1 per cent for an acre of wheat. If, however, a suspension of algae in water is circulated with exposure to sunlight, combined with enrichment of the atmosphere with carbon dioxide and the addition of nutrients, then a fixation efficiency of 5 per cent may be attained. The alga *Chlorella* may be grown in this way to produce food for cattle, and even for human consumption, but it is difficult to envisage that such processes will ever be practicable for fuel production.

The effective use of solar radiation as a source of energy therefore depends on further developments of artificial collectors and heat engine cycles, which will enable the conversion to be made at a cost comparable with that of existing fuel systems.

Operating Principles of Solar Radiation Collectors

Collectors may be divided into two groups: those in which the absorbing surface is fixed in position and which operate by direct illumination without any concentration; and those in which the absorbing surface is combined with a system of mirrors to concentrate the radiation. The latter necessarily rotate to follow the apparent motion of the Sun.

If a plate of sheet metal is exposed to direct solar radiation the temperature will rise until the rate at which energy is received is equalled by the rate at which heat is lost from the plate; this temperature is termed the equilibrium temperature. If the back of the plate is protected by heat-insulating material, the exposed surface of the plate painted dead-black and covered by one or two sheets of glass, then the equilibrium temperature will be much higher than for the simple exposed plate. This plate may be converted into a heat collector by adding a water-circulating system, either by making it hollow or by soldering copper pipes to the surface, and transferring the heated water to a tank for storage. If heat is taken away from the system, however, the equilibrium temperature must decrease, for no useful heat can be extracted at the maximum equilibrium temperature, at which the collection efficiency is zero. The other extreme condition is where the flow of water is so rapid that the temperature rise is very slight; then the losses are small and the efficiency of heat collection approaches 100 per cent, but as the temperature rise is so restricted the system has no practical utility. The optimum conditions are approximately midway between the atmospheric and the maximum equilibrium temperature, whereby an output of water at a useful temperature is obtained and the efficiency of radiation conversion is about 60 per cent. These flat-plate heat collectors are usually mounted on a roof in a fixed position, preferably facing south, and connected to a water storage tank by flow and return pipes so that a natural circulation is produced by the heating effect. Small units may be used for domestic hot-water supply and larger units with a correspondingly increased storage capacity for house heating. The same type of device may be used as an air heater, either for house heating or for the drying of fruit and vegetable crops.

The equilibrium temperature of the flat-plate collector is limited, because the area from which losses occur is equal to the area receiving radiation. If, however, a mirror system of relatively large area is used for concentrating the solar radiation upon a heat-absorbing area of smaller surface area, then the losses are proportionately reduced and the equilibrium temperature raised accordingly.

Whereas the flat-plate collector is in general restricted to a temperature somewhat below the normal boiling point of water, mirrors of sufficient size could theoretically reproduce the surface temperature of the Sun, 6,000° C. This would require a concentration in area of 40,000 (assuming the distance between the Earth and the Sun to be 100 times the diameter of the Sun), and neglecting any loss by reflexion at the surface of the mirrors. Practical applications are at the moment limited to a temperature of about 3,000° C., for which a concentration in area of 20,000 is required. Much smaller concentrations than this, say 10–100, are sufficient to raise steam at pressures above atmospheric, and quite simple mirror systems may be used for solar cookers. Mirror systems are generally in the form of paraboloids or parabolic cylinders.

Applications of Solar Energy

The application of flat-plate collectors to domestic water heating has been mentioned in the preceding section. There are no technical difficulties involved in this application; the problem is entirely an economic one based on the annual heating value of a square foot of roof area, determined by the price of fuel and the cost per square foot of the heat collector. In temperate climates, such as that of the United Kingdom or northern Europe, the annual heat collection per square foot of roof area could be about 1 therm (100,000 B.Th.U.). With coke at approximately 1*d.* per lb. and allowing for the efficiency of combustion, 1 therm of heat would cost about 1*s.*, but with electrical heating at 1*d.* per unit, 1 therm of heat would cost 2*s.* 6*d.* By using mass production methods of manufacture it might be possible to reduce the cost of heat collectors to 20*s.* a square foot, so that this cost could be recovered in eight years by replacing electrical heating, or in twenty years by replacing coke-fired boilers. The latter is not an economical proposition, but the former is just at the balance point, especially as the two methods could easily be combined by using solar radiation for preliminary heating and electricity for the final heating when needed. In contrast, however, to these conditions, in a semi-tropical country it would easily be possible to collect 2 therms/ft.^{2} annually, and electricity costs might be as high as 1*s.* per unit. The annual value of a square foot would then be 60*s.*, so that a solar water heater would recover its capital cost in a very short time.

A similar reasoning applies to house heating, provided that the climate is such that there is a sufficient proportion of winter sunshine. Several solar-heated houses have been constructed in the United States, some with heat storage by water, others using hot air with a large gravel bed for heat storage. A newly designed house at the Massachusetts Institute of Technology will have 80 per cent of the heating load during the year supplied by solar energy.

An office building in Albuquerque, New Mexico, designed by Bridgers and Paxton, has just been completed, in which most of the heating load is supplied by solar radiation. This system incorporates a heat pump to augment the heating in the coldest weather, and this can also be used for air cooling during the hot weather. These designs differ considerably from the conventional house, both in shape and construction, as the layout must incorporate the heat-collecting surface and the large storage capacity required to maintain the heating load during several cloudy days.

Solar-operated water stills for the production of drinking water from brackish water could be of benefit in arid areas such as exist in many parts of the Middle East or in Australia. The design must be cheap to construct, without the need for skilled attention, advantages which are possessed by the roof type of still. In this design the saline water is contained in a flat, shallow tray, which is covered by a roof type arrangement of sloping glass plates. The lower ends of the glass plates lead to troughs placed on each side of the large water tray. Solar radiation evaporates some of the water in the tray and the vapour condenses on the inside surface of the glass plates, so that drops of water run down the sloping glass and are collected in the side troughs. The output is about 1 lb. of distilled water per day per square foot of water tray area, and corresponds to a collection efficiency of about 30 per cent. More complex designs could attain higher efficiencies, but if the capital cost increased at the same rate as the output, no benefit would be obtained.

Mirror systems are used for attaining temperatures higher than the normal boiling point of water, such as are required for cooking. A concave mirror spun from sheet aluminium and about 3 ft. in diameter is the basis of a design by the National Physical Laboratory of India. This has an output equivalent to 300 watts and can be used for boiling or frying; it is intended for use in rural areas where fuel is scarce and will also enable animal waste products to be ploughed back into the land instead of being burnt as fuel. A team working under Prof. Farrington Daniels at the University of Wisconsin has developed similar cookers constructed from thin plastic with a coating of aluminium which has reduced the cost considerably. Solar ovens for baking bread have been designed by Dr. Maria Telkes, and attain temperatures of 350° F.

Although solar power was the objective of many of the early pioneers, there have been comparatively few recent experiments. Nevertheless, small power units for irrigation pumping could replace the very inefficient devices using human or animal power which are still employed in some parts of the world. One of the difficulties is that for an efficient heat cycle the working fluid should have a high temperature, which involves complex mirror-type collector. The flat-plate type collector with a small degree of mirror concentration is, however, able to vaporize volatile liquids such as sulphur dioxide, which is then used for driving an engine and pump. An installation working on this system has been developed by Italian engineers. Since fuel costs are not concerned, a relatively simple installation, even though of low efficiency, may well prove to be more economical than a complex installation of higher efficiency. It is reported that a solar power plant with a steam capacity of 12 tons/hr. (approximately 1,000 kW.) is to be constructed in the U.S.S.R., where there is an extensive Solar Engineering Laboratory.

Refrigeration and air-conditioning could be the most important applications of solar energy in tropical countries, but in this field also considerable research is needed. The present ammonia absorption systems require a temperature greater than is attained by the flat-plate collector, and though they could be operated by means of a mirror concentrating system, this would complicate the equipment. It is possible that the ammonia process may be redesigned for the lower temperatures or that other working fluids may be discovered.

The direct conversion of solar radiation to electricity is a fascinating prospect. Early attempts to accomplish this were by means of thermo-couples; these are junctions of dissimilar metals or alloys which produce an electric current when one junction is heated and the other cooled. As heat is an intermediate form of energy in the conversion, the process is subject to Carnot's law as regards efficiency, so that a high temperature for the heated junction is necessary to obtain satisfactory outputs. The ideal alloys for the thermo-elements possess properties which at present are conflicting, namely, a good conductivity for electricity and a poor conductivity for heat, combined with a high thermo-electric power. Experiments with existing alloys show efficiencies of 1–2 per cent at hot junction temperatures below 100° C., rising to 6 per cent at temperatures about 300° C.

The barrier-layer photo-voltaic cell converts the photons of light radiation directly into electricity by means of a flow of electrons in a layer of semiconductor. The familiar photocell used for many purposes has a thin layer of selenium as the light-sensitive material, but the efficiency of this type of cell in direct sunlight is 0·6 per cent. In 1954, Pearson, Chapin and Fuller, of the Bell Telephone Laboratories, developed an improved photo-voltaic cell with a silicon layer which converted solar radiation to electricity with an efficiency of 11 per cent. The basic layer of the cell is pure silicon containing one part in a million of arsenic, forming an *n*-type semiconductor. A trace of boron is diffused into the surface of this wafer, and converts the skin into a *p*-type semiconductor. Electron flow is produced when light falls upon the junction between these two layers, and the cell produces 0·6 volt on open circuit when illuminated by direct sunlight. A surface area of 1 square metre of these cells would give an output of 100 watts when exposed to bright sunlight, but the present cost of production limits the use to selected purposes such as power for portable radio transmitters and receivers, and for accumulator charging on telephone systems in remote areas. A substantial reduction of the cost would lead to numerous applications in localities where no other supply of electricity was available.

Solar Furnaces

Concentrated solar radiation was used by the alchemists for experiments on materials at high temperatures, and a system of lenses for this purpose was constructed by Lavoisier in 1772. Large lenses are too expensive and heavy, so that more recent furnace designs use mirrors for the concentration. Sir Henry Bessemer in 1868 constructed a solar furnace by which he was able to melt copper and volatilize zinc, but he abandoned this for more profitable work. Modern solar furnaces, though mainly used at present for research on materials at high temperatures, may eventually be found suitable for certain manufacturing processes.

The most impressive solar energy installation is the large solar furnace constructed by M. F. Trombe at Mont Louis in the French Pyrenees. A flat heliostat mirror is automatically controlled to move and direct the solar radiation along the axis of a concave mirror, 35 ft. in diameter, which is built up from 3,500 separate mirrors individually curved to the correct focus. The image of the Sun, about 3 in. in diameter, is projected into a rotating furnace in which high-grade refractories can be sintered or pure metals melted at temperatures up to 3,000° C.

The individual mirrors consist of segments of flat sheet mirror glass, but in order to obtain the degree of concentration needed for these high temperatures, each segment must be given the curvature necessary to form a focused image at the furnace opening. This is accomplished by straining each mirror by means of a spider frame with a rod passing through the centre of the mirror and a screwed nut for stressing the rod.

The advantage of the rotating furnace is that it may be partially filled with the material to be fused in a granular form, which by centrifugal force is held against the casing of the furnace. The cavity of the furnace acts as a black-body receiver, the innermost layers of material being fused first, and the fusion process gradually spreading through successive layers.

A still larger furnace with a concentrating mirror three times the area of the 35-ft. mirror is now being designed, and trial sections have been constructed. In addition to the existing furnace, M. Trombe has recently installed four smaller solar furnaces with 6-ft. mirrors very similar to that designed by Bessemer. These furnaces are to be available to research workers needing high temperatures for their experiments.

Future Possibilities

Solar energy could be used for almost all the purposes for which coal and oil are used at present, an exception being the field of power for transport. The practical applications of solar energy must be judged against future tendencies in the fuel supply situation and not entirely by present-day economics. Many of the applications which have been described above do not involve new principles, but success is dependent upon careful design and the introduction of new materials and methods of construction as these become available.

The technical problems as regards water heating, house heating and water distillation are virtually solved. When a demand for appliances for these purposes has been established, mass production methods of construction will greatly reduce the capital cost and make them even more attractive as competitors to normal fuels.

There is still scope for research to develop small solar power units using heat engine cycles, and even more so as regards the design of a really simple type of refrigerator operated at a comparatively low temperature. The Bell silicon photocell has great potentialities if only the cost of manufacture could be reduced a hundred-fold. Such an eventuality may be long deferred, but one would hesitate to say that it is impossible. Putnam, in a survey of world energy resources in the year 2050, has estimated that about 10 per cent of the heat required by mankind may be derived directly from solar energy, though only 0·1 per cent of power from the same source. Incidentally, nuclear fuels might at that time supply 60 per cent of the world's power requirements.

A beginning has been made in the study of chemical photosynthesis without the aid of living organisms. Chemical reactions that are promoted by light and are reversible may enable electricity or heat to be produced directly, or may be used for the production of combustible gases. Experiments have as yet been on a small scale, but it is quite possible that discoveries of far-reaching consequence will eventually be made.

It is evident that there is much scope in the future for the study of solar energy utilization. While nuclear energy can solve the power problem for the large cities and industrialized countries where the demands are high and continuous, solar energy may have more prospects of success in sparsely populated areas, especially if these are arid zones without normal fuel resources. As oil and coal gradually become more scarce and costly, so will the economic balance become more favourable for solar energy, and experience gained now may prove of the greatest value in the future. Research on solar energy ranges over many fields of science; the practical scientist could do much to solve the challenging problems of using this inexhaustible supply of energy for the benefit of mankind.

NEWS and VIEWS

Rutherford Memorial Appointments

UNDER the terms of the scheme to commemorate the late Lord Rutherford of Nelson, the following appointments have been made by the Council of the Royal Society: Prof. E. N. da C. Andrade, to deliver the Rutherford Memorial Lecture for 1957, which is to be given in Australia during September–October; Prof. P. M. S. Blackett, to deliver the Rutherford Memorial Lecture for 1958, which is to be given in Canada.

Mr. S. L. Surange, a graduate of the University of Lucknow, now working at the National Physical Laboratory of India, has been appointed Rutherford Scholar for three years from October 1, to carry out research in low-temperature physics at the Royal Society Mond Laboratory, Cambridge.

Royal Society Research Appointments

THE Council of the Royal Society has announced the following appointments: Dr. P. C. Caldwell, to an Alan Johnston, Lawrence and Moseley Research Fellowship, for two years in the first instance, from October 1; Dr. Caldwell will continue his research at the Marine Biological Laboratory, Plymouth, on the relationship between ion movements and metabolism in squid giant axons; Dr. M. J. R. Dawkins, to the Stothert Research Fellowship from October 1; Dr. Dawkins will carry out research in fœtal metabolism at University College Hospital Medical School, London.

Royal Society and Nuffield Foundation Commonwealth Bursaries

AWARDS under the Royal Society and Nuffield Foundation Commonwealth Bursaries scheme are announced as follows: Prof. S. D. Chatterjee, professor of physics at Jadavpur University, Calcutta, to enable him to study radiocarbon dating at the Royal Institution, London, and elsewhere in the United Kingdom, for four months from September 1957; Dr. K. Das Gupta, reader in physics, University College of Science, Calcutta, to enable him to work on soft X-ray spectroscopy at Liverpool for four months from June 1957; Dr. H. J. R. Dürr, senior entomologist, department of agriculture, University of Stellenbosch, to enable him to study the taxonomy of South African plant lice (Aphididae) at the British Museum (Natural History) and Commonwealth Institute of Entomology, London, for six months from December 1957; Dr. A. G. Fenton, senior lecturer in physics, University of Tasmania, to enable him to study intensity variations of cosmic rays, with particular reference to solar influences, at the Imperial College of Science and Technology, London, and the National Research Council Laboratories, Ottawa, between June 1957 and June 1958; Prof. Karimullah, professor of organic chemistry and director of the Institute of Chemistry, University of the Panjab, Lahore, to enable him to study natural products research techniques, etc., at Cambridge for about three months from July 1957; Dr. R. F. King, lecturer in geology, University of Birmingham, to enable him to see the application of geophysical methods to the search for oil and minerals and to study rock-magnetism in Canada during August–September 1957; Dr. L. J. Lawrence, senior lecturer in charge of geology, School of Mining Engineering and Applied Geology, New South Wales University of Technology, to enable him to study the latest developments in uranium mineralogy and mineral exploration for about six months at the Imperial College of Science and Technology, London, from January 1958; Dr. J. A. Pople, University lecturer in mathematics, Cambridge, to enable him to carry out research on the theory of nuclear magnetic resonance at the National Research Council Laboratories, Ottawa, during August–September 1957; Mr. J. Shaw, lecturer in zoology, University of Durham (King's College, Newcastle upon Tyne), to enable him to study osmotic and ionic regulation in East African freshwater crabs, at Makerere College, Uganda, during July–September 1957; Dr. J. Smart, University lecturer in zoology, Cambridge, to enable him to study black flies of New Guinea and adjacent islands, collecting there and studying in laboratories in Australia, between August 1957 and April 1958; Mr. H. V. Thompson, a principal scientific officer, Infestation Control Division of the Ministry of Agriculture, Fisheries and Food, Surbiton, Surrey, to assist him to visit Australia during October 1957–June 1958 for the purpose of studying myxomatosis as it affects the rabbit population and indirectly affects predators and agriculture in general.

Statistics at Birmingham: Dr. H. E. Daniels

DR. H. E. DANIELS, whose appointment to the newly established chair of statistics in the University of Birmingham has recently been announced, graduated first at Edinburgh, and then at Cambridge, where he was one of the late Dr. J. Wishart's students in statistics. From Cambridge he went to the Wool Research Association, and there was responsible for some pioneering applications of modern statistical methods to industry. In particular, he there began the work on components of variance which was specially cited in the award to him, this year, of the Guy Medal of the Royal Statistical Society. During the War, Dr. Daniels worked in Cunningham's Air Warfare Analysis Section on the applications of stochastic processes to gunnery problems and on statistical aspects of direction finding. After the War he joined his former teacher as lecturer on the staff of the Statistical Laboratory at Cambridge, and during Dr. Wishart's absence abroad, and since his untimely death (see *Nature*, 178, 294; 1956), Dr. Daniels has been acting director of the Laboratory. In this position he played a large part in building up the course for the diploma in mathematical statistics which has been taken by many of the best of Britain's meagre stock of younger qualified mathematical statisticians. His research interests might best be described as the solution, by methods typical of mathematical physics, of a very wide range of problems of mathematical statistics. His use of steepest descent methods to obtain the distribution of the serial correlation coefficient in the non-null case is a noteworthy example of this, while his contributions to the theory of stochastic processes have been characterized by their close connexion with physical and other practical applications.

Pierre Lyonet (1707–89)

ONE of the great amateurs in natural history and in the art of engraving, Pierre (Pieter) Lyonet was born 250 years ago on July 21, 1707, at Maastricht in the Netherlands. Descended from a French Protestant family that had been driven out of

Lorraine by Louis XIV, he was educated for the Protestant ministry, but took up law instead and became cypher-secretary and confidential translator to the United Provinces of Holland. He is said to have known at least eight languages. In 1742 he published a translation from German into French of F. C. Lesser's "Insectotheologie", with drawings and comments. Having taught himself the art of engraving, he supplied the plates for Abraham Trembley's "Mémoires". His most famous book, which has been described as the most laborious and beautiful example of minute anatomy that has ever been executed, is the "Traité anatomique de la Chenille, qui ronge le bois de Saule", published at The Hague in 1760. It is remarkable for the eighteen beautiful plates depicting his exquisitely delicate dissections of the head of the goat-moth caterpillar (*Cossus ligniperda*). Copies dated 1762 contain an extra plate showing the author's microscope and dissecting instruments, in answer to certain critics who had protested that such minute work was impossible and could not be genuine. Lyonet also studied the anatomy of the sheep-tick, the house-spider and various beetles, and the life-history of Diptera and Lepidoptera. Failing eyesight at the age of sixty put a stop to further microscopic investigations and to engraving. His later researches were published posthumously by W. de Haan under the title "Recherches sur l'Anatomie et les Métamorphoses de différentes espèces d'Insectes" (Paris, 2 vol., 1832). He was a foreign member of the Royal Society of London, and a member of the Royal Academies of Rouen and of Berlin, of the Imperial Academy of Natural History of St. Petersburg, and of the Society of Sciences of Holland. He died at The Hague on January 10, 1789, in his eighty-second year.

Discovery of Element 102

Element 102, as yet unnamed, has been discovered in the course of a joint research project by scientists from Sweden, Great Britain and the United States. In the experiments performed to make this new element, curium-244 deposited upon a thin foil was exposed to a stream of accelerated carbon ions generated by the 225-cm. cyclotron at the Nobel Institute, Stockholm. The carbon ions included both carbon-13 and carbon-12 particles. Absorption of carbon-13 particles in the curium led to the formation of element 102. The element 102 formed was collected on a separate foil placed near the target foil, along with other atoms produced and ejected by the interaction of the beam of particles and the target. The experiment required very close control of the energy of the incident beam of bombarding ions, since the probability of observing the formation of the new element is critically dependent upon the number of neutrons lost in the reaction; the number of neutrons lost in the reaction is increased, as the energy of the beam is increased beyond the lowest energy at which the reaction begins to occur. Element 102 was identified among the products on the capture foil by radiochemical methods; the isotope identified had a half-life of about 10 min. and emitted alpha-particles with an energy of 8·5 MeV. The isotope probably has a mass of 253 but this has not yet been established with certainty.

The members of the research team were: Hugo Atterling, physicist; Wilhelm Forsling and Lennart Holm, chemists; and Björn Alström, electrical engineer (Nobel Institute for Physics); John Milsted, chemist; and Alan Beadle, chemical technician (Harwell); Paul R. Fields, group leader in the Chemistry Division; and Arnold M. Friedman, who is working at Harwell for one year under an exchange of United States and British nuclear scientists (Argonne).

International Geophysical Year: Broadcast Warning Service

In order to assist the International Geophysical Year programme the B.B.C. is to broadcast information about the expected solar activity at 11.03 p.m. in the Home Service after the 'news' and before the weather forecast. It will be broadcast by all medium wave and very high frequency transmitters carrying the Home Service. Announcements will be made of the beginning and end of Special World Intervals, and preparatory warnings will be issued. This scheme was put into operation on July 15 and it will continue until the end of the International Geophysical Year (December 31, 1958).

The central World Warning Agency has been established at the United States National Bureau of Standards Radio Warning Service at Fort Belvoir, Virginia. There reports on solar activity from the Central Radio Propagation Laboratory at Boulder, Colorado, will be studied, and when it is considered likely that solar flares or other disturbances will occur on the Sun an 'alert' will be declared. If the activity is maintained a Special World Interval is declared. Should the expected activity fail to occur, the Special World Interval will be cut short. The 'alert' will be rescinded when the solar activity subsides or the active region disappears around the other limb of the Sun. In order to transmit information about the declaration of 'alerts' and Special World Intervals, use has been made of the existing meteorological communication system, which is used for transmitting weather information from one part of the world to another. The World Warning Messages initiated at Fort Belvoir will be transmitted by land-line to the transmitters in New York, Miami and San Francisco, and from there by a network of radio, telegraph and telephone links to meteorological communication centres and thence to International Geophysical Year stations. The messages will be transmitted from Fort Belvoir at 1600 U.T. (Universal Time, which is equivalent to Greenwich Mean Time), and if a Special World Interval is declared it will take effect at midnight on the same day. In Britain the messages will be received by the Meteorological Office Telecommunications Centre at Dunstable, and will be distributed by telegraph to scientific stations by the General Post Office and more widely by the B.B.C. announcements. The United Kingdom Antarctic stations will receive messages by radio from Port Stanley in the Falkland Islands.

Radiation Society of Australia

A highly successful conference on "Radiation Biology" was held at the Cancer Institute, Melbourne, in December 1955. This conference made apparent the number of people in Australia interested in the effects of radiation, and led to the suggestion of the formation of a Radiation Society. The Society is intended to lead to a better understanding among the workers in the various disciplines involved, and thereby to encourage research investigations. A committee has been elected, and comprises: Sir

Macfarlane Burnet (director, Walter and Eliza Hall Institute of Medical Research, Royal Melbourne Hospital), Dr. A. M. Clarke (Zoology Department, University of Melbourne), Mr. K. H. Clarke, Mr. H. A. S. van den Brenk, and Dr. J. H. Martin (convener) (Cancer Institute Board, Melbourne). A programme of four meetings for the year has been prepared, the intention of these first meetings being to cover fundamental concepts.

Earthquakes in Persia

BEGINNING on July 1, a series of strong earthquakes has caused devastation in the Caspian Sea region, east and north-east of Teheran, in northern Persia. In Shahi the main government building and railway station were damaged. Polour and Olesefid, villages near Demavend, were destroyed. Damage occurred in Larijan, Sangechal, Firuzkuh, Veresk and other towns and villages, including Bandpay and Bulukamiri. In all, casualties may amount to 4,000 killed, 10,000 wounded and 100,000 homeless. Minor earthquakes occur frequently in the district, and major earthquakes have occurred in the district in the past. In 1802 Demavend and Mazandaran and seventy towns and villages in the region were destroyed. Semnan and Damghan suffered great damage. In 1810 an earthquake caused much destruction at Sari. Another earthquake occurred at Demavend in June 1811. Sir Arnold T. Wilson refers to an inscription on the Masjid-i Juma at Barfurush which states that it was destroyed by an earthquake in the reign of Fath Ali Shah. Aftershocks of the present series are still occurring and further news from the area is awaited.

Earthquakes in Turkey

FOLLOWING the earthquakes at Fethiye less than a month ago and in Turkish Thrace on May 10, a severe earthquake shook the Bolu district on May 26 about 8.30 a.m. local time. This (*iP*) was recorded at Kew Observatory at 06 h. 38 m. 52 s. G.M.T. and the earthquake was of magnitude 7. The shock was felt at Istanbul (Bolu is 200 miles north-east of Istanbul) and in many places nearer Bolu. At Bolu there was great destruction of property including the water-works, and in the neighbourhood of Lake Aband, a beautiful summer resort, several villages were utterly destroyed. Three islands appeared temporarily, but later disappeared, and on nearby land there were cracks wide enough for a man to walk in. A mosque collapsed in Chakmacilar village, south of Bolu, and two hundred houses were wrecked in the town of Seben. Altogether some sixty-six people were killed and more than seventy injured. The epicentre was near latitude 41° N., longitude 31° E. and the origin time 06 h. 33 m. 31 s. G.M.T.; there have been more than seven hundred aftershocks from the same (or very near) epicentre. Five people were killed in an earthquake in Bolu in February 1956. Most earthquakes in Turkey are of tectonic origin occasioned by 'Alpine' orogenic pressure. When this pressure builds up so as to exceed that required for rupture, slipping occurs usually along one or more of the ancient geological faults which abound. One such structural line runs through Mürefte, Izmit, Bolu and Gerede, and although earthquakes have their epicentres on it, it also has a great influence on relief and is both a very densely peopled zone and a corridor for communications. One of the greatest of Turkish earthquakes occurred on December 27, 1939, near Erzincan. In this shock 16,629 buildings were completely destroyed, 9,599 partially destroyed, 23,148 people were killed and 8,029 injured (*Nature*, **145**, 13; 1940).

Centenary of the Science Museum

DURING the past and present decades many museums have or will celebrate their centenaries. It was a happy thought of the late Dr. F. Sherwood Taylor, director of the Science Museum, London, that the centenary of that Museum, which falls this year, should be celebrated by the publication of a book. Through his untimely death in 1956 it was, however, left to the present director, Mr. T. C. S. Morrison-Scott, to implement the inspiration of his predecessor, and he is to be congratulated on the production of a readable and interesting volume, entitled "The Science Museum: the First Hundred Years" (pp. iv+85. London: H.M. Stationery Office, 1957. 15*s*. net). The first part of the book gives a brief account of the history of the Museum from its inception in the Great Exhibition of 1851, its official opening to the public in 1857 in the 'Brompton Boilers', the opening of the east block by King George V in 1928, to the present day when the opening of the new Museum block is hopefully anticipated for the end of 1961.

It is stressed that the policy of the Science Museum is directed, first, to enlarging our knowledge of the development of science from the earliest times, and secondly, to presenting that knowledge to the visitor. To these ends the Museum has gathered together a collection of historic scientific and technological objects unsurpassed anywhere in the world. The second and larger part of the book is thus appropriately devoted to short descriptions of twenty-one of these historic objects. These have been selected with discretion, and include the Wells Cathedral clock (1392), the original Davy lamp (1816), the Pyrophone (*c*. 1874), the Rolls-Royce motor-car (1905) and the Whittle turbo-jet engine and Gloster aircraft (1941). The book is amply illustrated and is another example of the imaginative format which now characterizes the publications of H.M. Stationery Office.

Zoological Society of London

IN 1951 an ambitious plan for rebuilding the Society's Gardens in Regent's Park and for further developments at Whipsnade were announced. The implementation of this plan had to be deferred until the necessary financial resources were available. The Council of the Zoological Society has now commissioned Sir Hugh Casson to prepare, in association with the Society's architect, an alternative sketch plan for the rebuilding of the Regent's Park Gardens. The ultimate object is to transform the Gardens in such a way that the north end of Regent's Park becomes a major feature of London, both architecturally and from the landscape point of view, as well as the finest zoological garden in Europe. This proposal is described in the annual report of the Zoological Society (Report of the Council and Auditors for 1956. Pp. 63+4 plates. London: Zoological Society of London, 1957), which, besides all the relevant details of finance, visitors, new acquisitions and publications, explains the arrangements which have been made with Granada Television, Ltd., for the installation of a television unit in the Society's gardens.

Harwell Course on Isotopes in Industry

The Isotope School at Harwell is arranging a three-day course, during September 25–27, for directors and senior executives from industry, on the uses to which radioisotopes can be put. The course will include visits to the Harwell reactors and to the Wantage Radiation Laboratories, where research is progressing in the use of large radioactive sources for the irradiation of foodstuffs, pharmaceuticals and other manufactured articles. There will be talks on safety precautions to be taken when using radioactive material, and on aspects of turning an ordinary laboratory into an 'active' laboratory. Lectures will give sufficient background information to enable non-technical executives to appreciate the possibilities of the use of radioisotopes. The emphasis throughout will be on the practical uses of isotopes and irradiation sources in industry. Accommodation can be arranged at Worcester College, Oxford. The fee for the course will be £30 inclusive of all accommodation, transport, and meals. Forms of application and further information can be obtained from the Registrar, Isotope School, Atomic Energy Research Establishment, Harwell, Berkshire.

British Museum (Natural History) : Appointments

Dr. W. E. China, keeper of the Department of Entomology in the British Museum (Natural History), has been appointed a deputy chief scientific officer in succession to Dr. H. W. Parker (who has held that office in conjunction with the keepership of zoology); Dr. Francis Charles Fraser has been appointed keeper of the Department of Zoology in succession to Dr. Parker; and Mr. James David Macdonald a deputy keeper in the Department of Zoology; all with effect from October 1.

University News : Birmingham

The following appointments in the University of Birmingham are announced: Dr. W. I. Stephen, to be lecturer in chemistry from October 1; Dr. J. Wilcock, to be lecturer in industrial metallurgy from October 1; W. B. Powell, to be staff fellow in the Department of Physics from November 1; Dr. P. C. Harris, to be lecturer in medicine from July 1; Dr. K. Brown-Grant, to be lecturer in physiology from August 1. The title of reader in organic chemistry has been conferred on Dr. J. C. Tatlow.

London

Dr. H. C. K. Henderson, senior lecturer at Birkbeck College, has been appointed to the University readership in geography tenable at that College; and the title of reader in physics in the University of London has been conferred on Mr. W. R. S. Garton in respect of his post at the Imperial College of Science and Technology.

Sheffield

A gift of £25,000 has been made to the University of Sheffield by Imperial Chemical Industries, Ltd., towards the cost of building extensions to the Departments of Chemistry and of Fuel Technology and Chemical Engineering. The chemistry block in Brookhill, opened in 1954, was the first new teaching building to be erected under the University's development plan, but its capacity has already been overtaken by the increasing numbers of students. Plans have been prepared for the addition of an east wing with large teaching laboratories and a west wing for staff and research rooms. The first part of these extensions is due to begin this year. The Department of Chemistry is the largest in the University and had more than 550 students during the session 1956–57. The Department has not only to train specialists in chemistry and carry out fundamental research, for which it has acquired a distinguished reputation, but must also provide basic teaching for other students in the four Faculties of Pure Science, Medicine, Engineering and Metallurgy. It is in fact one of the key departments in the training of scientists and technologists. The Department of Fuel Technology and Chemical Engineering has for many years carried out valuable work in very cramped conditions at the University's Applied Science buildings at St. George's Square. In order that work on the efficient use of fuel and other industrial problems may go ahead as rapidly as possible considerable extensions to the Department's premises will soon be put in hand.

Announcements

Sir Charles Lillicrap, a former director of naval construction of the Admiralty, and Mr. John Strong, chairman of Quasi-Arc, Ltd., have been re-elected for a second year as president and vice-president, respectively, of the Institute of Welding.

Prof. A. C. Frazer, professor of medical biochemistry and pharmacology in the University of Birmingham, has been re-elected president of the British Food Manufacturing Industries Research Association.

Dr. Ralph W. Phillips, deputy director of the Agriculture Division of the Food and Agriculture Organization of the United Nations, has resigned to take up a new appointment as director of the Division of International Organization Affairs in the Foreign Agricultural Service in the United States Department of Agriculture. Dr. Phillips, a distinguished agriculturalist, has served with the Food and Agriculture Organization for more than ten years.

The Royal Society of Edinburgh has awarded a Robert Cormack Bequest Fellowship in astronomy to Miss Patricia R. R. Leslie, of Edinburgh. The Fellowship will be tenable for three years at the Cavendish Laboratory, Cambridge, and Miss Leslie will undertake research there, under Mr. Martin Ryle, into the distribution of the sources of extra-terrestrial radio emission. Miss Leslie is a graduate in pure physics of the University of Edinburgh.

The following have been elected to office in the Physical Society for the session 1957–58: *President*, Prof. N. F. Mott; *Honorary Secretaries*, Dr. C. G. Wynne, Dr. H. H. Hopkins; *Honorary Foreign Secretary*, Prof. E. N. da C. Andrade; *Honorary Treasurer*, A. J. Philpot; *Honorary Librarian*, Dr. R. W. B. Pearse; *Vice-Presidents*, Prof. S. Devons, Prof. F. Llewellyn Jones, Prof. H. Jones, and Dr. K. A. G. Mendelssohn.

The Chemical Research Laboratory, Teddington, Middlesex, is to hold three open days during October 1–3. Applications from firms for invitations should be sent to the Director not later than August 31.

Erratum. In the article entitled "Some Recent Advances in Spectroscopy" in *Nature* of June 29, on p. 1342, col. 2, line 51, for "lithium–potassium spectrum" read "lithium *K*-spectrum".

RESEARCH ON METAL COATINGS

BRITISH IRON AND STEEL RESEARCH ASSOCIATION, SOUTH WALES LABORATORIES

IN 1932 a research group was set up in the Metallurgy Department of University College, Swansea, to study various aspects of sheet steel production. It operated under the auspices of the South Wales Siemens Steel Research Committee and the Welsh Sheet and Plate Manufacturers' Association and was led by Mr. D. Luther Phillips.

When the British Iron and Steel Research Association was formed in 1945, it absorbed this research group, the functions of which were carried on by the Association's Mechanical Working Division. The policy of the British Iron and Steel Research Association had been to site its laboratories in areas traditionally devoted to specialized aspects of ferrous technology, so that it was natural that its Coatings Laboratory should be set up in South Wales, which is the main centre of the flat-rolling, tinning and galvanizing industry. In 1946 laboratory accommodation was obtained at Sketty Hall, a large building in Singleton Park, close to University College and about four miles from Swansea. A Pilot Plant Laboratory has recently been added in a building adjacent to Sketty Hall to house small-scale continuous strip-coating and processing plants. Mr. Phillips retired in 1954 and research is now directed by Mr. S. S. Carlisle.

The research programme of the Coatings Laboratory works in two main fields. It endeavours first to develop new and improved coating for steel, so as to extend the applications of steel products, and secondly, it seeks to improve such existing processes as strip tinning, galvanizing, aluminizing and lacquering in order to reduce costs and increase productivity. The ultimate aim is to prepare the way for automation in the steel strip finishing industry.

The many projects currently being studied at Sketty Hall were displayed at open days, held on June 19 and 21, when representatives from the iron and steel and allied industries toured the laboratories. A short description of the main displays is given here.

Research has been undertaken into coating steel with plastics, so as to combine the strength of steel with the attractive and durable finish of the plastic. An improved process has been devised, whereby a film of polyvinyl chloride is bonded to steel, the laminate so formed ('Plasteel') being amenable to bending, deep drawing and roller forming without harm to the plastic film. A pilot line is producing continuous strip laminate up to 3 in. wide in a variety of plain, coloured or embossed polyvinyl chloride on steel. The process is being patented, and wide interest has been shown by potential users of the new material.

It is an advantage in can-making to be able to apply a thicker coating to the inside than to the outside of a can, since the interior may be subjected to corrosive action from acid fruits. A problem in subsequent working of the tinplate is to identify which side has the thicker or thinner coat. A method developed by the Association, and being patented, is to dull one side by applying a thin electrodeposit of iron (about 0·25 micro-inch thick) after tinning but before flow brightening.

Lacquered steel has been found suitable for use in can-making where protection against corrosive fluids, other than acid fruits, is required. Although this is a useful technique when tin is scarce, lacquered steel has the disadvantages that it presents no tinned surface for soldering, it cannot be used for all food-packs, and the lacquer is easily damaged. However, it is now possible to tin the edges for soldering, and to lacquer one side of a sheet and tin the other. The British Iron and Steel Research Association has built an experimental line for lacquering steel strip, on which coatings of epoxy-resins up to 0·5 mil thick can be applied and cured by heating. A coating as little as 0·15 mil thick has been found to protect steel.

Thick coatings are more economically applied by hot-dip coating than by electro-deposition. The hot-dip technique also opens up the possibility of its application to high-speed strip working. Many studies of hot-metal coating practice have been made at the Laboratories, and a new method of hot-strip tinning has been developed.

It was decided to investigate applying tin to steel strip by roller coating, when the weight of tin applied could be controlled by varying the speed of the roller relative to the strip. An experimental continuous strip-coating line using this principle has been built, and good-quality coatings have been applied at speeds of up to 50 ft./min. Lead–tin alloy has also been successfully applied.

The process opens the possibility of cutting costs in tinplate production by placing the hot-tinning mechanism at the end of a continuous strip-annealing line. It may also be possible to use the process for applying such other coatings as zinc and aluminium, and it has therefore been decided to develop it further. To this end a 12-in.-wide strip-processing plant has been built, similar in principle to the small experimental line. It is capable of speeds up to 1,250 ft./min. and is fully instrumented.

A method for continuously coating steel strip with aluminium has been developed in the Laboratories, so making available a material generally resistant to corrosion and useful at temperatures too high for tin or zinc coating. The 'Sendzimir' process, which has been successfully operated in America, is mainly suitable for large-scale production of coated sheet, for which there is as yet insufficient demand in Britain. In the Association's method, continuous strip up to 3 in. wide has been successfully coated, and the difficulties normally encountered in the past from oxidation of the ingoing strip have been overcome. The surface of the strip is carefully prepared and coated with glycerol; it enters the aluminium bath through a protective box, preventing the oxide film which forms on the surface of the bath from reaching the strip. By burning the glycerol the strip is kept free from oxidation before entering the bath, also, and the addition of small amounts of silicon to the bath inhibits the formation of brittle iron–aluminium alloy on the steel surface. One firm has applied the Association's process to the manufacture of aluminized steel wire; aluminized steel, with its negligible tendency to scaling and its good anti-

corrosion properties, will probably become a material of greater application in the future.

Copper wire is being coated by drawing it through a die, the entry side of which is flooded with molten tin. Provided that the wire surface is clean and freshly drawn, no flux is needed; uniform coatings about 40 micro-inches thick with reductions in wire diameter of 5–10 per cent have been obtained and drawing speeds are about 100 ft./min. The process is being patented.

A necessary preparation for steel sheet or strip before working or coating is 'pickling' by immersion in sulphuric acid, which has the effect of removing the surface oxide film. The severe shortage of sulphuric acid a few years ago, coupled with the problem of disposing of spent pickle liquor, led the Association to investigate the possibility of recovering acid from waste liquor. This is achieved by precipitating ferrous sulphate monohydrate from the liquor by evaporation, roasting the sulphate to sulphur dioxide, and oxidizing this to sulphuric acid in a contact plant using vanadium as catalyst.

Several difficulties were encountered. Research had first to be undertaken to determine the practical limits to the removal of ferrous sulphate from acid solutions. The solubility curves so produced were an original contribution to the literature since the published data had been found inconsistent. Then it became evident that the relatively small output of sulphate from pickling lines made it uneconomic to use the contact process for its conversion to sulphuric acid. The Laboratories therefore developed an alternative process of autoxidation.

In this method, sulphur dioxide is released from the ferrous sulphate by roasting with coal and is then dissolved in weak acid circulated through an absorber tower from an acid storage tank. The acid with sulphur dioxide in solution is then aerated by having small bubbles of air blown through it. This takes place in a diffusion tank and the oxidation of sulphur dioxide to sulphuric acid occurs at the bubble–liquor interfaces, catalysed by manganese sulphate which has been added. The liquor is thus enriched in acid, which is drawn off to storage tanks for supply to the pickle line. The iron oxide residue from roasting the sulphate can be used as blast-furnace feed.

Trials on a pilot plant indicated that the process becomes economic when 10 tons or more of acid are being handled. With acid strengths above about 23 per cent the catalyst needs to be kept active by injecting a little ozone with the diffuser air; acid strengths of up to 40 per cent can then be provided. A plant has been designed which could treat all the ferrous sulphate processed at the Trostre tinplate works of the Steel Company of Wales, Ltd., and this design is now being considered. A plant has been proposed, also, for a closed-cycle pickling system with acid recovery using this autoxidation process.

VACUUM DEPOSITION OF METALS

A MEETING organized by the Department of Physics of the University of Cambridge and the British Scientific Instrument Research Association was held in the Cavendish Laboratory on May 17 and 18 by invitation of Prof. N. F. Mott. Attendance was by invitation, and scientists were present from the Imperial College of Science and Technology, London, the University of Bristol, Tube Investments, Ltd., the University of Cambridge and the British Scientific Instrument Research Association.

In the first paper of the meeting, Dr. D. W. Pashley (Tube Investments) described recent experiments on the occurrence of epitaxy in deposits of copper, lead and thallium on crystalline substrates. Dr. Pashley's experiments showed that, while the nature of the initial deposit varied, according to the metal, from a uniform monolayer to a scattering of widely separated atom aggregates, the crystalline form was always that of the metal itself, undistorted by the supporting crystal, which, nevertheless, imposed a regularity of orientation. Later in the discussion, Dr. M. Blackman (Imperial College) examined the relation, for a wide range of materials, between epitaxy and the degree of misfit between the lattice structure of the film and its substrate, and showed that in contradiction to the theory of Frank and van der Merwe there appeared to be no critical degree of misfit above which orientation of the film could not occur. Following Dr. Pashley's paper, which also included a mention of a new technique for revealing dislocations by means of a moiré pattern, Dr. A. J. Forty (Tube Investments) gave evidence of the role of crystal boundaries as sites for nuclei from which the growth of films could start.

Dr. K. M. Greenland (British Scientific Instrument Research Association) described in general terms the work which is being done from the point of view of new and improved detecting elements, and explained that, in the first instance, the British Scientific Instrument Research Association is concerned with the binding forces between films and their substrates with special reference to gold and silver on glass and silica.

Dr. J. W. Mitchell (University of Bristol) described an investigation of the texture of copper films deposited by evaporation at very low pressures on glass held at the temperature of liquid nitrogen. The surface area of the film was measured by an adsorption method. In these experiments it was found that the porous structure of the film was independent of the thickness. As the temperature of the film was raised the structure became more compact, but the admittance of oxygen had a strong stabilizing effect.

Mr. D. G. Anderson and Mr. J. E. Knowles (both from the British Scientific Instrument Research Association) continued the account of work at the laboratories of the Association. Mr. Knowles gave a description of a method which was being investigated for the comparison of the energy released when gold films condense on substrates of differing kinds. This method might lead to a direct measurement of the energy of reaction between the gold film and the substrate. Mr. Anderson showed how chemical bonds might be formed between metal films and a silica or glass substrate and described some experiments designed to demonstrate the importance of oxygen in film bonding. Taking account of the ionic nature of the glass structure, the possibility of the existence of reactive ionic centres in a fractured glass surface was also considered. Prof. F. C. Frank (University of Bristol) summarized the Frank–van der Merwe theory of critical misfit in epitaxy and also discussed the stability of nuclei of cubic crystal forms.

CHEMICAL ENGINEERING EDUCATION

THE symposium on chemical engineering education held at the University of Birmingham during April 9–11 should, as Mr. J. A. Oriel pointed out, be regarded as a domestic sequel to the conference sponsored by the Organization for European Economic Co-operation held in London in 1953. The symposium was arranged in four sessions covering the requirements of industry, methods of training, new trends in teaching, and recruitment to the profession.

After a welcome to the University and in particular to the new chemical engineering buildings by Prof. F. H. Garner, the first session was opened by Dr. D. Clayton (Imperial Chemical Industries), who spoke of the demands of the chemical industry. He explained that the new graduate may be employed in research, design or operation of plant and will receive training in all these spheres during his early years with a company. For this and other reasons, Dr. Clayton voiced the view generally supported by others, and certainly by the educational members at the symposium, that universities should concentrate on fundamentals. The additional technological training required can best be obtained 'on the job', provided that the graduate is already well grounded in basic sciences. In discussing post-graduate work, he felt more use should be made of the M.Sc. degree, as this gives a man an insight into research which is adequate for the majority. He explained that the chemical industry employs people with various forms and level of training, and that it is most important to have an adequate number of assistants if the maximum use is to be made of the best honours graduate. Prof. K. G. Denbigh later made reference to the lack in Britain, as compared with North America, of a large body of men trained just below honours standard.

Dr. F. Mayo (Esso) gave a clear indication of the urgent need for more chemical engineers when he stated that, of its combined intake of scientists and technologists, his company would like some 50 per cent to be chemical engineers, whereas it was only getting some 20 per cent. While welcoming the Government's new plans for technical education, he would press not only for their speedy implementation, but also for further consideration as to whether they are in fact adequate. Dr. Mayo stressed that the ideal process engineer needs imagination and an appreciation of the way in which another man's work influences his own. This can be achieved by movement of the young graduate through various departments, such as plant technical service, plant economics, process design and plant operation. It was his view that men trained in chemical engineering were much more flexible and easier to rotate than those trained in pure science. This is one of the reasons why men with this training are in such demand. He reiterated the point that the university graduate fails mainly in his lack of ability at writing reports and suggested that it takes his company about two years to correct this. He also thought that the American graduate settles down to active work rather more quickly than the British.

Mr. A. S. White (U.K. Atomic Energy Authority) explained the needs of the various Government departments with particular reference to the atomic energy establishments, which employ the greatest number of chemical engineers. In the research departments the main need is for good honours graduates, many of whom should have taken a research degree. There is a smaller need for the plant-manager type but an urgent need for design engineers. Here Mr. White put in a plea for more men with mechanical engineering training, such as might be obtained through a graduate apprenticeship. The experimental officer class provides a good opening for those who do not take honours degree courses.

The requirements of the chemical plant industry were put by Mr. J. P. V. Woollam and Mr. J. D. McFarlane (Simon Carves), who described the execution of a typical contract through the design, construction and commissioning stages, and they then outlined the qualities required by men taking up this type of work. They would like to see more graduates with a sense of cost consciousness, and they suggested that in the vacation the undergraduate should seek experience of general heavy engineering.

In opening the discussion, Sir Harold Hartley indicated the wide range of activities of the chemical engineer and his place in the optimizing of flow sheets. Chemical engineers by training are suited to making the right compromise in design. He felt that Dr. Clayton and Dr. Mayo rather under-rated the importance of research, because it is vital to have men coming forward who know where research can help. Dr. E. H. T. Hoblyn felt that the chemical engineer must do more on design, and that he was well fitted by wide training to be a project co-ordinator. He did not think that young engineers should become too divorced from plant itself and he regarded design problems as valuable in this respect. Prof. F. Morton went straight to the heart of the problem of the supply of teachers. If industry really wants more chemical engineers then it must make greater contributions to the universities. The lending of a few men to the universities to act as temporary academic staff for the next few critical years would make an enormous difference to the rate of growth, particularly of the newer departments in this subject. It would, he argued, be a good investment by industry.

Methods of Training

It is now clear that the majority of new graduates will have taken the undergraduate course, usually of three years. In discussing this type of course, Prof. F. H. Garner explained that, as the chemical engineer is primarily concerned with process industries, he should be trained to appreciate process design and plant efficiencies. On the operational side he must be introduced to efficiency of production and shown that this is effected by considerations of utilities, yields, human relations, and reliability of plant, as much as by pure technical calculations. The young chemical engineer must be trained to make decisions based on physical and chemical relationships, but he must learn that these relationships often have to be extended beyond their precisely known limits in order to solve problems in the time available. In that the chemical engineer would have to work with scientists of widely different training, he suggested that it is preferable for him to learn chemistry with the chemists; but in the discussion some members thought that more of the training should be in the hands of the chemical engineering department. The design problem he regarded as particularly suited for

tutorial instruction and it also provides an opportunity for the student to correlate much of his learning.

The development of the postgraduate diploma course was discussed by Prof. M. B. Donald (University College, London). This course had been formed by a marriage between chemistry and engineering, but the engineering content had been small. Of those taking these courses, some 95 per cent had previously studied chemistry, and there is little doubt that training in physical chemistry forms a valuable introduction to many features of chemical engineering. Mechanical engineers have a more difficult road in this respect. The main problem to-day is that the content of chemical engineering has been so extensively expanded that it is difficult to fit diploma candidates into the final year of the undergraduate course. There are special advantages in these courses for those who have been for a year or two in industry.

The position of the subject in technical colleges was given by Dr. P. F. R. Venables (Birmingham College of Technology). The number of candidates taking part-time courses is small, but the percentage of successful candidates has been high. There are eight colleges running these courses, but the response from industry has been small. Dr. Venables thought that the newer sandwich courses were more suitable for chemical engineering. The advantages of obtaining first-hand experience of industry at the same time as taking an academic course seem considerable in this subject. The total content of knowledge demanded by modern professional qualifications made it increasingly difficult for a man to train for these qualifications on a part-time basis. The part-time system is no longer adequate for educating modern technologists as distinct from providing a minimum training for them.

Mr. G. U. Hopton (North Thames Gas Board) explained the many difficulties of the lone man studying by private study. Such candidates for the examination for associateship of the Institution of Chemical Engineers should have trained in chemistry or in engineering by formal study before starting private study in chemical engineering. It is also essential for a man to be engaged in work of a chemical engineering nature.

New Trends in Teaching

Prof. E. S. Sellers (Swansea) explained the importance of mathematics as a tool in design, whether in analysis or in synthesis. Physical design, including the optimization of variables, cannot be done successfully without mathematical tools, and the teaching of mathematics must therefore be associated with its physical and chemical applications. He outlined a three-year course, the main feature of which was the integration of mathematics with chemical engineering in the last year, when the application of mathematics would be given by the chemical engineering department mainly in the form of problems.

Thermodynamics was indicated by Prof. K. G. Denbigh (Edinburgh) as one of the basic studies of chemical engineers. He suggested that a generous provision should be made for this work, both because of its utility and also because of its educational value. It was important to give a real discussion of fundamentals, as the natural inclination of engineering students was to concentrate on the application of a tool. He indicated the application of thermodynamics in several parts of the subject, including its less generally realized use in the calculation of manufacturing processes.

Dr. F. Rumford described the practical training scheme run by the Royal College of Science and Technology, Glasgow. There is no doubt that practical training on industrial units for a short period forms an ideal complement to the theoretical training of the lecture rooms. Realization of some of the difficulties with large units assists the beginner in forming an opinion of the merits and limitations of theoretical work. It must be remembered that these courses do not, and cannot, provide real training in plant operation, and the industrialists must be prepared to provide extended practical training for all graduates. This is one of the difficulties facing small firms, but there can be no doubt that careful training schemes will bring out the best in the new recruit. Plant manufacturers are equally involved in this problem.

Prof. J. M. Coulson (Durham) traced the changing attitude to unit operations, which had been the basis of the initial courses in this subject. The main change in the past fifteen years had been in the co-ordination of these operations and their reclassification as aspects of heat transfer, mass transfer and momentum transfer. In so doing we had created chemical engineering science, in which the study of the basic mechanisms of interphase transfer was predominant. With regard to the future, he suggested that it would be wrong to regard chemical engineering science as synonymous with chemical engineering. He put in a plea for encouragement of the inventive mind, particularly with regard to new forms of equipment. Men leaving British educational establishments should not only have a feeling for cost consciousness but also a sense of urgency.

Opportunities and Recruitment

The third session, on recruitment to the profession, was opened by Mr. A. A. Part (under-secretary, Ministry of Education), who, in speaking of the technological awakening, indicated the brighter prospects for technological training. He warned the conference that the opportunities for chemical engineers must be brought home much more strongly to school-boys and their parents. A strong and up-to-date pattern of courses must be developed which must receive determined support from industry. Mr. Part mentioned that the so-called 'post-war bulge' will increase the numbers in the eighteen-year-old group, from the present figure of 640,000, to 850,000 in 1965. The increasing tendency, 5 per cent per annum, for boys and girls to stay at school until the age of eighteen will further increase the number of potential university and technical college students. With regard to quality, he noted that 51 per cent of the State scholarship winners of 1955 were going to read science or technology. The schools had moved over to science, but the need now is for a move to technology. He was particularly anxious that the profession should make a clear statement regarding its demands for space in the technical colleges, as preparations must be started at once.

Mr. R. Groves (High Master of Dulwich) gave a most interesting account of science-training in British schools, emphasizing that science is now firmly established as a desirable course. The aim is to produce cultured young people who are educated as well as trained in vocational subjects. In the sixth form all should be devoting some time to writing English and to

studying a foreign language. He asked industrial members whether they could not do more for the science masters at the schools, perhaps by providing some possibilities for research, but certainly by showing a real interest in them. He took the opportunity of thanking industry for making so marked a contribution to the problem of laboratories in the independent schools.

Mr. J. A. Oriel (president of the Institution of Chemical Engineers) maintained that the opportunities for chemical engineers are excellent and that the profession is showing a most vigorous growth. He claimed that Britain needs at least five times as many chemical engineers leaving the various educational establishments as at present, and that the opportunities for new recruits are excellent. The process industries throughout the world are experiencing a period of outstanding growth, and central to their progress lies the chemical engineer. Referring to the petroleum industry, Mr. Oriel instanced the developments in the past thirty-five years, but he believed there was an even brighter future ahead. In Britain, chemical engineers are almost equally divided between research, development, construction and operation. In North America, with its longer period of development in this field, chemical engineers are in administration in a greater proportion than chemists or other engineers.

In reviewing the symposium, Prof. D. M. Newitt (Imperial College of Science and Technology) thought that industrialists were right in placing emphasis on character development rather than on functional efficiency, but he maintained that a period of post-graduate studies was of greater value than indicated by the industrial members. He thought that we should probably change the nature of our training even more rapidly. Present syllabuses tend to be a legacy of the past and could with advantage be given a new look. Chemical engineering science could conveniently be regarded as a link between physical sciences and technology, and he gave a brief outline of proposals on these lines, in which the traditional studies of mechanical and electrical engineers were merged into chemical engineering science.

J. M. COULSON

WOMEN IN INDUSTRY

WHEN the history of the twentieth century is written, the year 1957 will surely be noted, *inter alia*, as the one when women really began to press their claims for equal career opportunities with men. Their efforts to secure equal social rights through equal educational opportunities has met with considerable success, and, within a few years, they should achieve equal material rewards for equal work. In many activities, and especially in the professions, they have reached positions of eminence and few doors still remain closed to them. In one sphere, however, they have made little progress. This, of course, is the world of industry, and during the past few months the voice of woman has been raised in many parts of the world protesting against the domination of man in industrial and commercial activities. In Britain that voice has been heard at various conferences and courses, while powerful arguments for career emancipation have been propounded in all kinds of journals.

It was appropriate, therefore, for the British Federation of University Women to form a working party to examine all the opportunities open to girls and women with qualifications in science and technology. Its report* has now been published and contains details of jobs available to girls and women in industry, the professions, agriculture and the Armed Forces. The compendium has been painstakingly prepared, and, in the section dealing with openings in the professions and Armed Forces, will be invaluable to headmistresses and university authorities, parents and girls in their formative years; details of jobs are accompanied by details of qualifications needed to fill them.

In the sections concerned with opportunities in industry, however—and these are very few in a report of this size—the working party has been less than fair to members of their own sex who wish to take up work in industry. Perhaps it was unfortunate that only one of the working party of twenty-four women appears to have had definite experience in industry and that in a specialist job.

If the working party had included one or two women members with experience of management in industry—the managing director of Boxfoldia would have been an excellent choice—more attention might have been paid to the very real difficulties confronting a girl who is keen on an industrial career. Although there is still considerable male prejudice against the employment of able women in industry, not all men are prejudiced; there are real difficulties and these must be squarely faced if they are to be overcome.

First, women, like men, would have to see that, although it has other functions, industry must make profits or it would cease to be. The comparative security of the past twenty years has led to great emphasis on the 'service' aspects of industry. This is surely right and cannot be over-stressed. But manufacturing industry can never be a service in the same sense as a profession like medicine, and the competitive element cannot be eliminated. Aspiring women, therefore, should be clearly told that, while industry overall has a social purpose, many industrial firms fail every day and many more are likely to do so. They should accept, too, that industry has not settled patterns of promotion like many professions and the Armed Services and that, even to-day, many men in senior positions have little formal education or training; the secrets of success in industry are still far from clear.

It should also be made clear that many of the openings in industry described in the report will lead to important specialist positions in industry but not to senior positions; the latter will still go to those who are able to co-ordinate the work of the specialist. It is surprising that a report of this kind could be prepared without including the word 'management'; that appears to be the case. Women graduates, too, should be warned that in many industrial organizations which employ male graduates, the latter are finding it difficult to make headway against traditional rule-of-thumb methods of management.

The real difficulty, however, which must be overcome before women are accepted in senior positions in industry is the question of marriage and child-bearing. These topics are not mentioned in the report. Yet if a manufacturer is faced with two people for a key appointment, he is unlikely to provide expensive training for one on whom the odds of leaving are much greater than the other. It is little use telling him that this training will not be lost to

* Opportunities for Girls and Women in Science and Technology. 2s. net.

industry as a whole; he looks at his balance sheet and there may be a loss to him.

Such manufacturers will only take women applicants when there are no suitable male applicants. Fortunately for professional women, that condition has already been reached in many branches of British industry. Women will be accepted because there is no other choice. Women should think carefully, however, before deciding on particular careers in industry. In such careers as general management, personnel management, and industrial medicine, a break for marriage and child-bearing should be no handicap and should enable the middle-aged women to return to industry even more fitted for her job. In rapidly evolving specialist fields, however, where knowledge of chemistry, physics and other natural sciences are involved, she may find it easy to secure a post before marriage but difficult to return to it afterwards.

Women who wish to find employment in industry may find this report disappointing; they should be consoled by the knowledge that industry can no longer do without them.

EARLY HISTORY OF THE SAUROPSID REPTILES

IN palæontology, as in other branches of science, small things often lead to great and far-reaching results. It is not unexpected, therefore, that Prof. D. M. S. Watson, with his usual searching eye and his vast knowledge of reptilian structure, should develop some significant conclusions from his study of eight small reptilian skulls and associated skeletal materials, contained in a nodule of rock from the *Cistecephalus* zone of the Karroo series of South Africa. These fossil remains, representing the genus *Millerosaurus*, are described in detail in a recent paper* by Prof. Watson in which he turns to a discussion of the basic classification and the relationships of all the reptiles.

Millerosaurus, as Watson shows, is a small fossil reptile with a long body and slender limbs. The skull is basically cotylosaurian, but it has a well-developed lateral temporal fenestra, situated beneath the post-orbital and squamosal bones. A part of the skull roof is covered with bony osteoderms fused to the underlying skull bones, and at the back of the skull the quadrate is characterized by a long ascending process rising to the supratemporal bone. In the area behind these bones is a small stapes, quite comparable to the stapes of a lizard, which in life must have formed a communication between a large tympanic membrane and the fenestra ovalis. The pectoral girdle has a 'screw-shaped' glenoid, and in the hind foot the fifth digit is complete and divergent. The fifth metatarsal is straight—not a hook-shaped bone. Such are a few of the bare facts concerning the osteology of *Millerosaurus*. What are the implications?

In 1916 Goodrich saw a basic dichotomy within all but the most primitive reptiles, the two branches of which he designated the Sauropsida and the Theropsida. Watson upholds this view of reptilian evolution, and he places *Millerosaurus* and its relatives as very important ancestors of sauropsids. In line with previous work, he believes the ear region to be of particular diagnostic value in the determination of sauropsid and theropsid relationships. Thus *Millerosaurus* is an ancestral sauropsid, in part because it has the type of ear structure briefly described above. (In the theropsids, according to Watson, the tympanic membrane was lost for some time during late Palæozoic times, and in later forms was re-established as a neomorphic structure, not homologous with the tympanic membrane of the sauropsids. This part of his thesis is disputed by some authorities, notably Vaughan in a recent contribution.)

Because of the important situation of the millerosaurs (as *Millerosaurus* and its near relatives may be designated) in time and in their taxonomic position, this study throws light on many other reptiles and on the whole subject of reptilian classification. Watson believes that the temporal fenestræ are of secondary importance in determining reptilian relationships. He suggests that the millerosaurs, which are essentially cotylosaurs with lateral temporal fenestræ, might well have been ancestral to the prolacertilian reptiles, to the eosuchians and to the great thecodont–archosaur complex; in short, to sauropsids, which comprise the great majority of reptiles through time. He believes that the evolution of the diadectids may represent an entirely separate reptilian development, parallel to the rise of the procolophonid–millerosaur stem, the true base for the sauropsids.

Watson's conclusions are of broad consequence to students of reptilian evolution, and the accumulating mass of evidence would seem to reinforce these ideas. Since the concept of an early dichotomy of evolving reptiles is of such significance to future work in this field it is perhaps unfortunate that Goodrich's term 'Theropsida' is being continued. This word might well be abandoned in favour of some other name that is less apt to get confused in many minds, and particularly in many typewriters and printing presses, with the long-established taxonomic designation 'Therapsida'. Indeed, though not so serious a case, the term Sauropsida bears too strong a resemblance to Sauropoda for complete comfort. Could we not have two new names for the two primary lines of reptilian evolution?

EDWIN H. COLBERT

* *Phil. Trans. Roy. Soc.*, B, No. 673, **240**, 325 (1957): On *Millerosaurus* and the Early History of the Sauropsid Reptiles. By Prof. D. M. S. Watson. (London: Royal Society, 1957.) 25*s*.

FILTER FEEDING IN FLAMINGOES

FILTER feeding is very rare among the higher vertebrates—among the mammals it occurs only in the whalebone whales, and among the birds in the Anatidae and in some species of a few other families. It reaches its highest development in the flamingoes, in which it has been investigated by Miss Penelope M. Jenkin, who reports her results in a recent memoir*.

There are six species of flamingo according to some authorities, or four, one of which is divided into three sub-species, according to others; they are partitioned between three genera. Flamingoes are widely distributed throughout the warmer regions of both Old and New Worlds, and their distribution is determined by the situation of the salt or alkaline lakes where their food occurs in abundance. They thus congregate near the great deserts of the world, often at high altitudes. When Miss Jenkin was working on the

* *Phil. Trans. Roy. Soc.*, B, No. 674, **240**, 401 (1957): The Filter Feeding and Food of Flamingoes (Phoenicopteri). By Penelope M. Jenkin. (London, Royal Society, 1957.) 35*s*. 6*d*.

ecology of alkaline lakes during the Percy Sladen Expedition to the Rift Valley Lakes in Kenya she was able to watch two species of flamingo feeding, and established that one of them, *Phoeniconaias minor*, feeds exclusively on minute blue-green algae and diatoms. An extremely fine filter is necessary to separate such minute organisms from the water, and further examination showed that the mesh of the filter mechanism in this species is of the order of only 0·01 mm. across. In the other species, *Phoenicopterus antiquorum*, the filter is much coarser with a mesh of about 0·5 mm. × 1·0 mm., and the food consists of such comparatively large organisms as chironomid larvæ, small molluscs and crustaceans and seeds of lacustrine plants. The two species can therefore feed in the same lake without competing for food.

A transverse section of the bill of a flamingo shows a median ridge in the roof of the mouth that causes the palate to be V-shaped in section, with each limb of the V opposing the corresponding inner surface of the mandible. In some species, the "shallow keeled" forms, the angle of the V is obtuse; in others, the "deep keeled" forms, it is acute and the opposing surfaces are comparatively much larger. Beneath the apex of the V the tongue, more or less circular in section, fills a corresponding groove between the rami of the mandible. Two rows of recurved hooks on its dorsal surface fit into the spaces on each side between maxilla and mandible. The opposing surfaces of the jaws are beset with rows of lamellæ broken up into small plat lets, which in some species have fringed edges so that they show a remarkable resemblance to the baleen of whalebone whales on a minute scale. At the margins of the jaws there is a series of much larger lamellæ or hooks, "the excluders", each corresponding to several rows of the finer lamellæ.

All species of flamingo wade or swim in the water and depress the head into such a position that the upper surface of the upper jaw is directed downwards, a posture which is facilitated by the downward curvature of the distal part of the bill. The head is swept from side to side in wide curves either at the surface or below it according to the species and the type of food sought. At the same time the fleshy tongue is moved to and fro in its groove like a piston so that water is pumped in and out of the mouth. On the suction stroke the jaws are slightly separated to break the filter and allow particles of a size that can pass the excluders to enter the mouth with the water. On the exhaust stroke the jaws are approximated so that the particles are retained on the filter as the water is expelled through it. On the following suction stroke the particles are removed from the filter and passed backwards towards the œsophagus by the recurved spines on the surface of the tongue. The movement of the bill produces an action analogous to that of woolcarders, so that the enmeshed particles are gathered together and presented to the hooks on the tongue.

Flamingoes are not, as has been claimed, monophagous. They eat any organisms that pass the excluders and are retained by the filters, and if the diet is limited to one species that is an ecological accident. When as a result of 'over fishing' or of climatic factors all the organisms that can be collected have disappeared, the flamingoes move to new feeding grounds—they are notoriously erratic in their appearances and breeding sites. But if the normal food supply runs short when they cannot depart because they are tied to a particular area where they are nesting they resort to feeding upon mud, and obtain their nourishment from the organic matter, diatoms and debris, included in it.

Miss Jenkins emphasizes the importance of filter feeding to flamingoes feeding in lakes where the waters differ osmotically and in ionic balance from the body fluids of the birds. By concentrating the food organisms a minimum of the physiologically unsuitable medium is ingested, with a consequent easing of the burden placed upon the kidneys. Filter feeding, in addition to its use in obtaining nourishment, appears to have an equally important function in preventing excess salts from passing beyond the bill into the alimentary canal. In support of this conclusion the author adduces the well-known fact that flamingoes periodically leave their feeding grounds to drink at fresh-water sources.

Finally, Miss Jenkin discusses the affinities and evolution of the flamingoes, and concludes that they are descended from early anseriiform ancestors and that they occupy an intermediate position between the Anseriiformes and the Ciconiiformes.

The author is to be congratulated upon a most interesting and important series of researches which have occupied her attention for a considerable time. As ever in original investigation, her results, while recording numerous hitherto unknown facts, raise a considerable number of new problems which, it is to be hoped, she or her pupils will have the opportunity of resolving.

L. Harrison Matthews

THE SITE OF THE NEUROHYPOPHYSIAL OSMORECEPTORS

THROUGH the classical work of Verney in the 1940's, presented so elegantly in his Croonian lecture (*Proc. Roy. Soc.*, B, **135**, 25; 1947), a physiological mechanism was elucidated by which the organism is able to regulate its water loss with the urine. A series of elegant experiments accomplished under fully physiological conditions in the dog led Verney to the conception of osmoreceptors situated in the brain, within the distribution area of the internal carotid artery. These receptors, when activated by a normal or raised osmotic pressure of the blood, send impulses to the neurohypophysis to release the antidiuretic hormone.

Recently, P. A. Jewell and Prof. E. B. Verney, in an extensive paper*, have summarized ten years continued work in this field. In a long series of laborious experiments, performed with the utmost carefulness, skill and inventiveness, they have been able to show that neurohypophysial osmoreceptors are localized within the anterior hypothalamus and, perhaps, also within adjacent parts of the pre-optic area. What makes this work so valuable and decisive is the fact that here as in Verney's earlier experiments they have exclusively used blood-borne, physiological stimuli on unanæsthetized animals.

It is not possible to do justice to this work within the limits of a short review, but some of the main points may be mentioned.

To trace the arterial blood, which in the different experiments had carried the osmotic stimuli, it was first necessary to make a careful anatomical study of

* *Phil. Trans. Roy. Soc.*, B, No. 672, **240**, 197 (1957): An Experimental Attempt to Determine the Site of the Neurohypophysial Osmoreceptors in the Dog. By P. A. Jewell and Prof. E. B. Verney. (London: Royal Society, 1957.) 52*s.* 6*d.*

the arterial connexions of the circle of Willis and of the detailed vascular architecture of the diencephalon and the hypophysis in the dog, and further, with the help of suitable coloured substances, to study the distribution of vertebral and carotid blood in the brain. These careful studies of the vascular supply of the dog's brain will certainly be of the greatest value to anyone who, in the future, traces the distribution of arterially injected substances in the brain of the dog.

After an account of these preliminary studies, the authors describe experiments performed to localize the osmoreceptors. Having tested the antidiuretic response obtained from infusions of hypertonic saline into the common carotids in dogs supplied with carotid loops but otherwise intact, they started to study the effect of tying one or more of the carotid branches supplying the brain with blood. Tying of the branches of the internal carotid intradurally, especially, necessitated a very delicate operative technique. After killing the animals, the distribution areas of both carotids were traced with the help of coloured substances. In all cases where an antidiuretic response to infusions of hypertonic saline was obtained on the side of the brain where the distribution of carotid blood had been restricted, the anterior hypothalamus and adjacent parts of the pre-optic area had been reached by hypertonic blood. No other part of the brain was reached directly by the infusions. The authors thus have good reason to conclude that the neurohypophysial osmoreceptors are localized in the anterior hypothalamus and perhaps also parts of the pre-optic area.

The results of the last two experiments reported in the work might at first sight seem somewhat confusing. In these, all three main branches of the internal carotid had been tied intradurally on one side, leaving some smaller branches to supply the ipsilateral parts of the hypothalamus with arterial blood. The result in both cases was that the antidiuretic response seen before the operation, due to intracarotid infusions of hypertonic saline, vanished completely. The occlusion of these three branches of the internal carotid had, however, in one of the dogs, caused the formation of a cyst in the anterior hypothalamus, and a reduction in the number of cells in the remaining nuclei. In the other dog a large cyst was formed in the thalamus, and the greater part of the anterior hypothalamus had been supplied from the carotid of the opposite side. This seems in itself to be a possible explanation for the lack of response to the infusion of hypertonic saline on the side operated upon.

On the basis of these two experiments, and of other observations which cannot be mentioned here, the authors put forward the interesting hypothesis that the functioning of the hypothalamic osmoreceptors may be dependent upon the integrity of nervous connexions with the thalamic paraventricular nucleus. Further experiments to test the validity of this hypothesis are suggested at the end of the paper.

In short, this solid work of Jewell and Verney forms an extremely valuable complement to Verney's earlier pioneering research on the physiological regulation of the function of the neurohypophysis. Their results have meanwhile been fully supported by the work carried out at the Royal Veterinary College of Stockholm by B. Andersson and his collaborators, who have been able to elicit not only thirst, but also an inhibition of water diuresis in conscious goats, by electrical stimulation within the anterior hypothalamus.

Yngve Zotterman

MOSAIC EVOLUTION IN HYDROIDS

In many animals different organs are capable of undergoing independent evolution at different rates. The idea of 'mosaic evolution' is becoming familiar to systematists in a number of groups. It both enriches the story of phylogeny, and bedevils those classifications that have relied on a few 'good taxonomic characters'. In the hydroid cœlenterates, moreover, the two phases of the life-history—polype and medusa—have an almost independent existence, and it is peculiarly easy for them to evolve separately and each acquire new characters not apparent in the morphology of the other. In traditional classifications, the polype and medusa of the same species have often had different names, separate families and have been described by different workers. Realization of this was not wanting, even in 1864 with Allmann's lament that "the principles of classification that have been regarded as the only sound ones in other groups have been almost entirely ignored in our attempts at a systematic arrangement of the Hydroida".

With modern knowledge the need for dual classification is ending, and in a recent report* by Dr. W. J. Rees, proposing a new arrangement of the capitate hydroids, a large advance has been made. Dr. Rees has, for the first time, merged polypes and medusæ into a single phylogenetic classification; and in this he has had much careful work to draw upon, especially the studies of Russell, Kramp and himself. This must be an important paper for the hydroid specialist; and it is a stimulating one for the general zoologist who is fond of hydroids or teaches marine biology. The author gives a lucid account of the suborder Capitata, drawing his evidence widely from both polype and medusa, with particular attention to the relation of form and function in his own experience of living hydroids. The resulting classification is a 'liberal' and broad-based one.

Theories of alternation of generations (there seems no good reason to avoid this term) are reviewed. The older hydroid theory held the sexually propagating polype to be the primary form in Hydrozoa. The medusa arose from a later 'division of labour', though this hypothesis could never properly account for the Trachylina. Dr. Rees firmly supports Brooks's theory (now most widely accepted) of the ancestral role of the simple 'actinula', which gradually took advantage of attachment, and by vegetative proliferation gave rise to a polypoid phase. The earliest hydroid was probably a primitive medusa, comparable with a trachylinid, and the medusal theory and actinula theory are in fact complementary.

The body of the paper is a consideration of evolutionary trends and mosaic patterns developed in the polype and the medusa. Dr. Rees rejects Kramp's view that the colonial corynoids are the most primitive polypes: colonial forms—he holds—have arisen from solitary forms, and the existing lower Corymorphines come nearest to the ancestral form of the hydroid polype. Here we have types like *Hypolytus* and *Euphysa* with a feeble perisarc, no diaphragm and no well-developed stem canals. The oral tentacles are capitate or moniliform but the aboral circlet always moniliform, corresponding with the tentacles of the

* Bulletin of the British Museum (Natural History). Zoology. Vol. 4, No. 9: Evolutionary Trends in the Classification of Capitate Hydroids and Medusæ. By Dr. William J. Rees. Pp. 453–534 + plates 12 and 13. (London: British Museum (Natural History), 1957.) 25s.

early medusa. In these lower polypes they form the long fishing tentacles suited to life on a muddy substrate. Capitate tentacles arose later. Polypes have evolved along three broad lines. In the *Corymorpha–Tubularia–Margelopsis* line, we find the largest and most elaborate polypes, the Tubulariidae acquiring a firm perisarc and settling on hard substrata, and the margelopsid polypes becoming specialized and pelagic. The larger polypes of this line develop a most complex internal structure; *Corymorpha nutans* is 11·4 cm. in length, *Brachiocerianthus imperator* a giant of 224 cm. In the second or *Acaulis–Myriothela* line, starting with the primitive *Acaulis*, the polypes become vermiform, with short capitate tentacles scattered over the intertentacular area. *Myriothela austrogeorgiae* reaches 30 cm. in length. The third series—the corynoids—have become colonial, with the individual polypes much smaller, and the aboral tentacles lost, as in the "deceptively simple polypes of the Corynidae". Food circulates from polype to polype by a continuous cœnosarc, and in the higher corynoid family, the Zancleidae, Russell and Rees have found sexual and nutritive differentiation among the polypes (elsewhere much more emphasized among Hydroida).

The position of the gonophores, egg size and encystment and evolution of the perisac are considered, followed by a survey of evolution in the medusæ. Dr. Rees regards the medusæ of capitate hydroids (the Codonidae of Haeckel) as the most primitive of all. The ancestral form—not unlike a modern *Sarsia*—had a deep bell-shaped umbrella with scattered nematocysts, four per-radial tentacles with moniliform nematocyst batteries, four radial canals, a ring canal and a ring gonad surrounding the stomach. Moniliform tentacles are retained in many corymorphine polypes, but only *Euphysa* has them in both polype and medusa.

Dr. Rees agrees with Broch and Kramp that the condition of the gonophore—an attached sporosac or a free medusa—is by itself of little taxonomic value. But the free medusa has much higher claims: it is not so much an organ only a little removed from a fixed eumedusoid, but an independent organism undergoing its own evolution. Its morphology, duration of life and reproductive behaviour carry great weight in discrimination of species, genera and even families. Many species find "fuller opportunity for expression in a free planktonic phase than in a sedentary benthic phase".

Phyletic lines of polypes and medusae are summarized in two schematic figures (57, 58). Generalized though these must be, they might have been even more helpful to the non-expert if they could have been given fuller captions. Dr. Rees's classification introduces four superfamilies into the suborder Capitata of order Anthomedusae. The Tubularoidea contains the Corymorphidae, Tubulariidae and Margelopsidae; the Tricyclusoidea is set up for the unique species *Tricyclusa singularis*. The Acauloidea includes the Acaulidae and Myriothelidae; and in the Corynoidea are grouped ten colonial families with simple hydranths centring around the Corynidae. For some of these, such as the Cladocorynidae and Asyncorynidae, this grouping is provisional and common ancestry is not claimed. J. E. MORTON

HOW DOES THE EHRLICH ASCITES TUMOUR OBTAIN ITS ENERGY FOR GROWTH?

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IN the peritoneal cavity of the mouse, cells of the Ehrlich ascites tumour multiply rapidly. After transplantation their number increases about 25-fold within five or six days. This growth is accompanied by a corresponding increase of ascitic fluid.

Since the ascitic fluid contains only traces of glucose and oxygen[1], it seems surprising that the cells can grow in this medium. In the course of recent experiments *in vitro*, Warburg[2] "placed varying amounts of energy at the disposal" of the ascites cells and then transplanted them. He observed that the cells died when neither glucose nor oxygen was supplied for twenty-four hours, but that "one-fifth of their growth energy" was sufficient to preserve transplantability. Though these experiments seem to show that ascites cancer cells can survive under conditions of near-starvation, the question still remains as to how they find the energy for *growth* in the ascitic fluid.

Glucose Concentration and Glycolysis

It is well known from Warburg's experiments with surviving tumour slices that a glucose concentration of about 200 mgm./100 ml. is required for maximum glycolysis. At glucose concentrations lower than 80 mgm./100 ml. the rate of glycolysis decreases sharply, amounting to less than one-fifth of its maximum at a glucose-level of 5 mgm./100 ml. A similar relation between glucose concentration and fermentation has been found with cell suspensions, for example, with yeast cells. Here, too, the rate of fermentation diminishes considerably once the glucose concentration has dropped below 200 mgm./100 ml.

When we became interested in the metabolism of the ascites tumour cells *in vivo*, we first inquired into their glycolysis in relation to the glucose concentration in the medium. This seemed necessary in view of the extremely low level of glucose in the ascitic fluid. We found that, *in vitro*, the maximum rate of glycolysis is still maintained at a glucose concentration as low as 4 mgm./100 ml. Once the level of glucose has fallen off to about 3 mgm./100 ml., glycolysis ceases abruptly. Ehrlich ascites tumour cells would thus be able to make full use of their glycolysing capacity, if the ascitic fluid were to contain a minimum of about 4 mgm./100 ml. of glucose.

Concentration of Glucose in the Ascitic Fluid

As far as we have been able to ascertain, the concentration of glucose in the ascitic fluid has not yet been accurately determined. Since the amounts of glucose present in the fluid are too small to be estimated quantitatively by the usual methods, we

adopted the following procedure. Immediately after the withdrawal, the ascitic fluid was mixed with 4 volumes of ethanol, centrifuged and the supernatant fluid evaporated under reduced pressure. The residue was suspended in 5 per cent trichloro-acetic acid so as to bring it to the original volume of the ascitic fluid. After adding 1 mgm. of charcoal per ml., the suspension was centrifuged. The glucose concentration in the clear supernatant fluid was then determined colorimetrically with the aid of the anthron–sulphuric acid reagent. Irrespective of the age of the transplant 5–7 mgm./100 ml. of glucose were found, a concentration at which glycolysis of the tumour cells is at its maximum.

Source of the Glucose

From measurements of the metabolism of ascites tumour cells *in vitro*, Warburg and Hiepler[1] have calculated how much glucose the cancer cells, present in 5 ml. ascitic fluid, would glycolyse if they used their glycolysing capacity to the full: under anaerobic conditions they could glycolyse about 44 mgm. of glucose per hour and under aerobic conditions half that amount. As we have seen that the glucose concentration in the ascitic fluid is above the optimum for the glycolysis of the cancer cells, it can be inferred that the influx of glucose is adequate. Nevertheless, we have also attempted to assess experimentally the rate of influx of glucose into the ascitic fluid. Normal mice were injected intraperitoneally with 5 ml. of ascitic fluid made cell-free by centrifugation. This fluid contained 3 mgm./100 ml. of glucose. When it was withdrawn 3 min. after the injection, the glucose concentration had risen to 17 mgm./100 ml. Thus, 14 mgm. of glucose could diffuse into 5 ml. of ascitic fluid within one hour. This amount would not fully meet the requirements of the cancer cells for maximum glycolysis under aerobic conditions. However, one important factor had to be omitted from our experiment, namely, the ascites tumour. The tumour cells keep the glucose-level low in the surrounding medium and thus enhance the flow of glucose through the capillary walls into the ascitic fluid. Conversely, in the cell-free ascitic fluid with its rising glucose concentration, the influx of glucose will progressively slow down. For this reason we chose the shortest possible interval of time, namely, 3 min., to determine the rate of influx. Even at the end of so short a period, however, the glucose had already risen to a higher level than is found at any time in the ascitic fluid of a mouse bearing the ascites tumour. If we make allowance for this unfavourable factor in our experiment, it would appear that the amount of glucose which diffuses into the ascitic fluid is large enough to keep the cancer cells saturated under aerobic conditions.

At first sight it seems surprising that such large quantities of glucose should be available in a mouse. Its blood and liver together contain less than 50 mgm. of carbohydrate, while more than 500 mgm. of glucose is consumed in twenty-four hours by the cancer cells present in 5 ml. of ascitic fluid. Where does all the glucose come from?

In the ascitic fluid of a tumour-bearing mouse the lactic acid concentration is maintained at a level of about 100–150 mgm./100 ml. by the glycolysing cancer cells. We have followed the absorption of the lactic acid by injecting 5 ml. of cell-free ascitic fluid intraperitoneally into normal mice. Ten minutes after the injection the concentration of lactic acid in the ascitic fluid had on the average dropped by 44 mgm./100 ml. Thus, at least 13 mgm. of lactic acid could be absorbed from 5 ml. ascitic fluid within one hour. Some of the lactic acid might be oxidized by the cancer cells; the major portion, however, will be absorbed into the blood-stream and transformed by the liver into glycogen, which, in its turn, will replenish the blood with glucose. In this way, the greater part of the glucose, glycolysed by the cancer cells, will re-enter the ascitic fluid and once more be available for glycolysis. Thus it appears that in spite of the very great consumption and the low concentration of glucose in the ascitic fluid, ascites tumour cells, no less than other cancer cells, are able to derive a major part of their energy for growth from glycolysis.

We are indebted to Dr. G. Klein, Stockholm, for supplying us with the Ehrlich ascites tumour. A detailed account of our experiments will appear elsewhere.

[1] Warburg, O., and Hiepler, E., *Z. Naturf.*, **7b**, 193 (1952).
[2] Warburg, O., *Science*, **123**, 309 (1956).

SEISMIC RECORDINGS OF ATOMIC EXPLOSIONS IN AUSTRALIA

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During September and October 1956 four atomic weapons were exploded in South Australia. At the suggestion of Sir Edward Bullard, and with the co-operation of the British Atomic Weapons Research Establishment, the ground waves produced by these blasts were recorded at seven different localities, mainly near stations on the Trans-Australian railway. This unusually long and straight railway passes through the desert of the Nullarbor Plain and so provides a useful traverse of low noise-level along which to record seismic waves from the weapon trials area at Maralinga, which is situated towards the eastern end of the line (Fig. 1). The geology of this plain may be simply described as horizontally bedded Miocene limestone, known to be 900 ft. thick in places, with the Yilgarn Pre-Cambrian Shield to the west and possibly underneath the limestones. The three most distant stations were on the Yilgarn Shield.

An attempt was made to record at roughly 2° intervals to as great a distance as possible. Records were obtained out to a distance of 10·7°, and it may be possible to extend this distance in future recordings.

At six of the stations, instruments of high gain and fast paper-speed were used, and at the other a Willmore seismograph. The former instruments, which were built by Dr. P. G. Gane for similar work in South Africa, consisted of a vertical and a horizontal

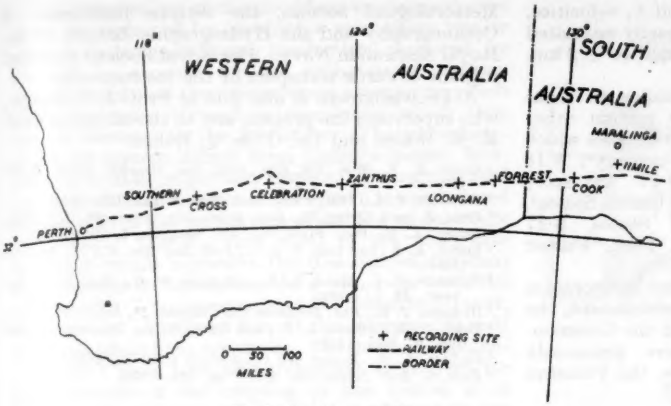

Fig. 1. Location of stations

geophone (orientated longitudinally) with natural periods about 0·6 sec., two amplifiers and a three-galvanometer recorder of paper-speed about 2 cm./sec. Time-marking was provided by chronometers together with recording of W.W.V. radio time-signals on one of the galvanometers. Arrival-times could be read to 0·1 sec. quite easily on the records of the fast recorders, and to 0·5 sec. on the Willmore record.

The times of the explosions and their geographical co-ordinates were supplied by the Atomic Weapons Research Establishment. All four explosions were used, but only one explosion was recorded at each station. The positions of the recording sites were calculated from railway survey data and State Lands Department maps. Geocentric distances were then calculated using the formula 2 vers $\Delta = (a - A)^2 + (b - B)^2 + (c - C)^2$. The standard error of the distances so obtained[1] is 0·6 km. Height and ellipticity corrections of the observed times were not applied, being less than 0·1 sec.

Only phases that are easily discerned in the records are reported in this communication. As can be seen from inspection of Fig. 2, most phases lie close to one of four straight travel-time curves. Two of these were interpreted as P_n and S_n. The others were designated P_1 and S_1 and are discussed below. With the exception of P_1, the times were fitted to linear t—Δ relations by the method of least squares.

P waves. The P_1 phase was recorded as the first arrival at the closest two stations, as the second arrival at Forrest (3·18°) and possibly as a later arrival at Loongana (4·11°).

Owing to uncertainty in measuring the travel-time to the closest station, only the Cook and Forrest results were used to calculate the P_1 velocity. The resultant value of 6·12 km./sec. with a time intercept of 0·2 sec. indicates that P_1 is apparently the P-wave velocity immediately below the sediments.

The second velocity, 8·23 ± 0·02 km./sec., was calculated from the four first arrivals from Forrest to Celebration and was taken to be P_n. This value was calculated using the mean earth radius 6,371 km., so that the result is directly comparable with that of other investigators. Use of the radius to the Mohorovičić discontinuity will lower this velocity by approximately 0·05 km./sec. The second arrival at Cook also lies close to the P_n curve, but may be a reflexion from the Mohorovičić discontinuity. The standard deviation of the residuals from a linear relationship was 0·12 sec., compared with Willmore's value[2] of 0·19 sec. for the Heligoland experiment. The small residuals show that the P_n curve is close to linearity, out to 8·7°. Since the records were obtained in only one direction, this velocity could have a systematic error due to dip of the Mohorovičić discontinuity. At the outermost station, Southern Cross (10·7°), the residual obtained by extrapolating the 8·23 km./sec. curve to this distance is −1·9 sec. This large residual is evidence of a possible bend in the P_n travel-time curve between 8·7° and 10·7° due to an increase of velocity with depth.

Our P_n and S_n travel-times were respectively 6 and 14 sec. earlier than those given in the Jeffreys–Bullen tables for 10°. Other possible P-phases are shown in Fig. 2, but these do not indicate any additional layers.

S waves. At most stations two later arrivals were recorded, usually with slightly larger amplitudes and longer periods (0·1–0·2 sec.). The arrival-times were fitted to two straight travel-time curves, giving velocities of 4·75 ± 0·02 km./sec. (using the mean earth radius), and 3·56 ± 0·03 km./sec. These waves were interpreted as S_n and S_1.

Except for Southern Cross, where the noise-level was high at the time, S_1 was recorded at all stations, in contrast to P_1 which was observed only as far as Loongana (4·1°). The greater range of S_1 is possibly due to conversion to the surface wave L_g with increasing distance, as suggested by Press and Ewing[3].

Bullen[4] found evidence for the occurrence of a prominent S-phase in New Zealand records of near earthquakes, and Bullen and Bolt[5] found similar evidence in records of a South Australian earthquake. This phase had an estimated velocity of 3·7 km./sec., and was designated S^*. P^* was thought to be less prominent and P_g and S_g doubtful. It is therefore suggested that our P_1 and S_1 correspond to the P^* and S^* of earlier analyses of near earthquakes.

The P_n and S_n time intercepts were 7·56 and 14·76 sec. respectively. Assuming a uniform 'crust'

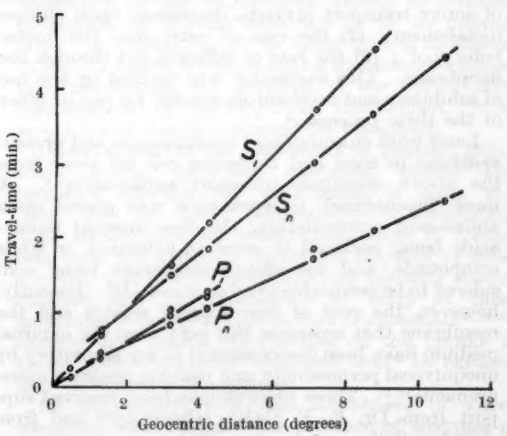

Fig. 2. Travel-time curves

in which the velocities are these P_1 and S_1 velocities, the depth to the discontinuity was formally estimated as 35 ± 2 km. using the *P*-wave data, and 40 ± 2 km. using the *S*-wave data.

The results of this survey are similar to those obtained by recording explosions in certain other continental regions; for example, P_n velocities which have been measured are: North Germany[2], 8·18 km./sec.; Western Transvaal[4], 8·27 km./sec.; Canadian Shield[7], 7·91–8·21 km./sec.; United States[8], 8·1 km./sec.; Wisconsin[9], United States, 8·17 km./sec.; Pennsylvania[10] and New York, United States, 8·14 km./sec.

This work was made possible by the co-operation of the Atomic Weapons Research Establishment, the Australian Department of Supply and the Commonwealth Railways. Instruments were generously loaned by the Bernard Price Institute, the Pakistan Meteorological Service, the Scripps Institution of Oceanography and the Hydrographic Branch of the Royal Australian Navy. The Royal Society provided a grant towards transport of the instruments.

Acknowledgment is also due to Prof. J. C. Jaeger, who supervised the project, and to the advice of Prof. K. E. Bullen and Dr. G. de Q. Robin.

[1] Bullen, K. E., *Mon. Not. Roy. Astro. Soc., Geophys. Supp.*, **3**, 190 (1934).
[2] Willmore, P. L., *Phil. Trans. Roy. Soc.*, A, **242**, 123 (1949).
[3] Press, F., and Ewing, M., *Bull. Seism. Soc. Amer.*, **43**, 219 (1952).
[4] Bullen, K. E., Proc. Sixth Pac. Sci. Congress, **1**, 103 (1939).
[5] Bullen, K. E., and Bolt, B. A., *J. Proc. Roy. Soc. N.S.W.*, **90**, 1, 19 (1956).
[6] Willmore, P. L., Hales, A. L., and Gane, P. G., *Bull. Seism. Soc. Amer.*, **42**, 53 (1952).
[7] Hodgson, J. H., *Pub. Dominion Obs., Ottawa*, **16**, No. 5 (1953).
[8] Tatel, H. E., Adams, L. H., and Tuve, M. A., *Proc. Amer. Phil. Soc.*, **97**, 658 (1953).
[9] Slichter, L. B., Report *N*9 *ONR*-86200 (Oct. 31, 1951).
[10] Katz, S., *Bull. Seism. Soc. Amer.*, **45**, 303 (1955).

A GENERAL THEORY OF MEMBRANE TRANSPORT FROM STUDIES OF BACTERIA

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IT has recently become evident that the basic problem of membrane-transport (even in the cases of sodium and potassium ions) is concerned with the movement of chemical groups through the membrane[1,2]. In this article I shall therefore consider the problem of membrane-transport in terms of the relationship between 'biochemical' group-transfer reactions[3] and 'biophysical' membrane-transport reactions, breaking with the tradition that has allowed the extensive studies of electrolyte movement complicated by bioelectric potentials to dominate the field of membrane-transport. The work that I shall describe will suggest a general theory[4] which might be restricted to bacteria, but for reasons that will become obvious, it is more likely that the mechanisms of membrane-transport will show the same general uniformity in different genera as do those of metabolism.

Some years ago, I suggested[5] that the internal concentration of free glutamic acid in streptococci is determined by three rate processes: (1) the rate of active transport inwards, dependent upon glucose metabolism; (2) the rate of entry into the 'metabolic pool'; (3) the rate of diffusion out through the membrane. This suggestion was verified by the use of inhibitors and accelerators specific for one or other of the three processes[6].

Later work on amino-acid accumulation and protein synthesis in cocci and *Bacterium coli* led away from the above membrane-transport explanation[7,8]. A more 'biochemical' interpretation was placed upon amino-acid accumulation, the free internal amino-acids being assumed to exist as activated or labile compounds, and the plasma-membrane being considered to be permeable to all amino-acids[9]. Recently, however, the pool of free internal solutes and the membrane that separates this pool from the external medium have been demonstrated in my laboratory by unequivocal permeability and osmotic pressure measurements[10,11]. These observations have received support from Dr. E. F. Gale's laboratory[12] and from elsewhere[13–15].

With the return to favour of the membrane-transport view of the accumulation of certain amino-acids, two facts which accorded with the more 'biochemical' interpretation have, however, still to be explained: first, the entry of these amino-acids into internal protein and external peptides without passage through the internal free amino-acid pool[6]; and second, the rapid exchange of certain analogous amino-acids (for example, valine and *iso*leucine) with one another across the membrane[16]. I shall return to these facts later.

It has been shown by the use of tracers that the plasma-membrane of resting staphylococci prevents a net flow of phosphate, but permits a quite rapid strictly reciprocal exchange between the inorganic phosphate molecules on either side. When, however, the cells respire in glucose, the flow of phosphate inwards remains unchanged, but the outflow approaches zero, so that phosphate is transported inwards. These and other facts led to the conclusion that the same translocation mechanism operates in the exchange and uptake, and that one may analyse the translocation process of active transport by studying the exchange reaction in resting cells[16,17]. Kinetic studies indicated that the rate of the phosphate-exchange reaction is proportional to the degree of saturation of an externally accessible reactant with $H_2PO_4^-$, just as the rate of an enzyme-catalysed reaction is proportional to the degree of saturation of the enzyme with its substrate. Moreover, the reactant in the plasma-membrane displays enzymic specificity towards the $H_2PO_4^-$, and the exchange reaction is susceptible to specific inhibitors all of which also inhibit the active transport[11]. Only arsenate can be substituted effectively for phosphate, the exchange of arsenate for phosphate across the membrane being as strictly coupled as that of phosphate for phosphate. The transport of arsenate can consequently be driven against a concentration gradient by the reverse movement of phosphate in resting cells.

The observations on the phosphate-exchange system could be explained by invoking a mechanism similar to the exchange-diffusion mechanism proposed by Ussing[18] to account for the exchange of sodium. He suggested that the ions saturate a carrier on which they may pass through a membrane which they cannot traverse in the free state. The phosphate-exchange system differs from Ussing's model, however, in a most important respect. Ussing[3] pointed out that when the carrier of his system is unsaturated on one side of the membrane, a net flow of substrate will occur. The K_m (0·8 mM) of the phosphate exchange would represent the dissociation constant of the carrier in Ussing's model; yet, even when the external $H_2PO_4^-$ concentration was lowered to 0·1 mM, there was no significant flow of the internal 100 mM inorganic phosphate outwards. The simplest explanation that I have been able to suggest to account for the strictness of the coupling in this system is as follows: phosphorylated carriers are present in the membrane, the phosphoryl groups of which, due to thermal movements, become alternately accessible to the media on either side where a specific exchange may occur between the phosphoryl groups on the carriers and phosphate ions without loss of the bond-energy of the carrier-phosphoryl compound[10]. In this system the carrier-ion compound (or complex) is not in equilibrium with its hydrolysis (or dissociation) products as it is in Ussing's system. The explanation that I have suggested amounts to making a strict analogy between the translocator and the combining centre of a group-transferring enzyme; for group-transferring enzymes are known to form intermediate covalent compounds with the group that they transfer from one substrate to another[3,19].

Gourley's observation[20] that phosphate may be carried through the membrane of erythrocytes as adenosine triphosphate led to the suggestion that the phosphate-exchange system of staphylococci might operate with adenosine triphosphate as the carrier and phosphokinases as the enzymes catalysing the exchange. But I pointed out that if this were so, the strongly lipophobic properties of adenosine triphosphate would almost certainly have to be masked by some large molecule such as a protein of low solubility in water in company with which it would have to pass across the osmotic barrier by a translational or rotational movement of the large molecule[16]. This is a quite different conception from Goldacre's theory, supported by Danielli[21], that contractile enzymes cause active transport by forcing the solute mechanically through the membrane. According to Prankerd[22], phosphate uptake in erythrocytes may be enzymically linked to the conversion of 3-glyceraldehyde phosphate to 1,3-diphosphoglycerate close to the cell surface; but while perhaps implying direct participation of glyceraldehyde-3 phosphate dehydrogenase, he states that "enzymes do not necessarily play any intimate role in the actual movement of any substance". In contrast to this, the view that I am stressing here is that the oxido-reduction and group-transferring enzymes of classical biochemistry do in fact catalyse (but do not force) the movement of a chemical group from one substrate (or coenzyme) to another on or within the enzyme molecule. It is therefore logical to consider[23] that the catalysts of translocation may be proteins identical to normal enzymes, the translocation being a normal enzymic attribute when the enzyme forms part of the membrane[10,11]. It is, of course, conceivable

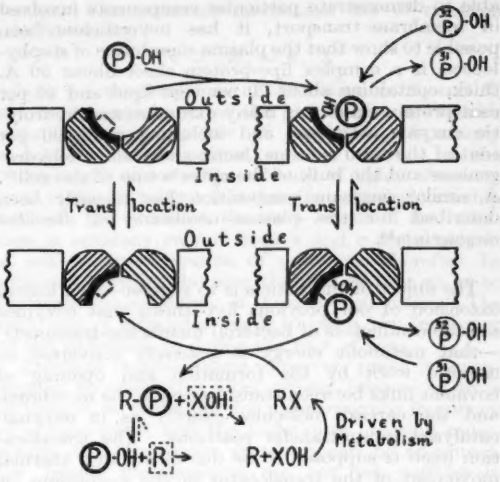

Fig. 1

that protein catalysts of translocation may lack chemical catalytic function. In either case the name 'translocase' might aptly be used, although in the former the normal biochemical name of the enzyme concerned might be quite sufficient. The molecular group covalently linked to the substrate during translocation—which may be a small molecule such as a lipid or nucleotide, or may be the combining centre of a translocase—will be called the 'translocator'. The characteristics of the phosphate-exchange reaction are summarized diagrammatically in the right side of Fig. 1. The ringed P represents phosphoryl as HPO_3^-; the black area, the 'translocator'; and the shaded area, the translocase. Although the translocator has been depicted as moving bodily in the membrane, it might alternatively be so placed in relation to the translocase as to be accessible to its substrate from either side without itself undergoing a strictly molecular movement, but rather an electronic one.

During respiration in glucose, phosphate is actively transported inwards by a process which inhibits the outward passage of phosphate but not the outward movement of the carrier. This may be caused by the occupation of the translocator during its outward movement by another substrate or by an internal bond. A mechanism of the latter type is illustrated in Fig. 1; and in a corresponding substrate-exchange-type mechanism, the group X of the hydrolysable intermediate of carbohydrate metabolism, R–X, would travel out in exchange for phosphate.

Observations on the movement of glucose, galactose, lactate, pyruvate, succinate, malate and fumarate through the membranes of cocci and *Bact. coli* by direct permeability measurements have shown that the plasma-membrane of resting cells does not permit a significant net flow of these solutes; and kinetic, metabolic and inhibitor studies indicate that the mechanism of entry of these substrates is closely similar to that of phosphate[10,11,24]. Genetic and kinetic observations on the uptake of amino-acids[13,25], sugars[14] and citric acid[26] by bacteria may be similarly interpreted.

An enzymically controlled mechanism of active transport would require the presence of enzymes in the plasma-membrane. While we have not yet been

able to demonstrate particular components involved in membrane-transport, it has nevertheless been possible to show that the plasma-membrane of staphylococci is a complex lipo-protein sheet about 50 A. thick, containing about 20 per cent lipid and 40 per cent protein exhibiting many oxidative and hydrolytic enzyme activities, and including some 90 per cent of the total succinic, lactic and formic dehydrogenases and the bulk of the cytochrome of the cell[27]. A similar enzymic composition has recently been described for the plasma-membrane of *Bacillus megaterium*[28].

The object of this article is to suggest—as a logical extension of our previous hypothesis that enzymes are the conductors of bacterial membrane-transport[11]—that metabolic energy is generally converted to osmotic work by the formation and opening of covalent links between translocators in the membrane and the carried molecules exactly as in enzyme-catalysed group-transfer reactions. The translocation itself is supposed to be due either to a thermal movement of the translocator in the membrane, or to the simultaneous accessibility of the translocator from both sides; and this movement or availability may be determined by a normal enzyme (or perhaps by a special protein), which we may call a translocase. The efficiency of the osmotic process could thus be equivalent to that of classical group-transfer reactions. I have described elsewhere how a reaction of this type may drive the movement of ions such as sodium and potassium which are supposed not to form covalent bonds[4].

The displacement of analogues that occurs during accumulation of amino-acids[13] and also of sugars[14] cannot, as Cohen and Rickenberg have pointed out, be adequately explained by the quantitative counterpart of the kinetic scheme described above for glutamic acid transport, in connexion with which they and Buttin and Monod have introduced the term 'permease'. It can, however, be explained by the type of system that I am now proposing, since exchange-translocation may occur in the active transport channel with any pair of substrates that can both use the translocator. Reactions 1 and 2 of the scheme described above are more closely linked than was at first suspected, and reaction 3 may be negligibly slow under normal conditions.

The fact that external amino-acids may form internal protein or external peptides without entering the free amino-acid pool would be explained by the uptake of the amino-acids into the membrane as covalent translocator (that is, activated) compounds. Further, the synthesis of the polypeptides and polysaccharides[29] of the cell-wall outside the plasma-membrane may be similarly explained.

The active transport may be driven by covalently bound metabolic end-products such as carbonic or other organic acids[19] which pass outwards on the translocators and are exchanged for nutrients at the outer surface of the membrane. Alternatively the translocators may have internal bonds, such, for example, as the diphosphopyridine nucleotide-thiol bond of glyceraldehyde-3-phosphate dehydrogenase[30] or the –S–S– form of lipoic acid[31], which may be opened by the entry of the reactant approaching from outside the membrane and closed again by coupling with oxido-reductions when in contact with the inner medium.

Such a close linkage of membrane-transport with metabolism would explain the long-standing anomaly[32] of the low physical permeability of cell membranes and the comparatively easy accessibility of the metabolic systems to the nutrients of the medium.

In view of the facts discussed in this article, I suggest that, since it has not yet been strictly defined, the word 'permease' (by analogy with hydrolase) should be reserved to describe protein catalysts of facilitated permeation or diffusion which might, for example, play the part of the hydrolytic or dissociation-type carrier of Ussing's exchange-diffusion system. If a word outside the normal nomenclature of enzymes should be desirable to describe the type of translocation catalyst considered here, it would be appropriate to use the term 'translocase' (by analogy with transferase); for the reaction catalysed is the translocation across the membrane of a covalently-bound group which is in equilibrium, not with its hydrolysis or dissociation products (as is the bound group in facilitated permeation or diffusion), but with the metabolic intermediates that give rise to the active transport.

I am indebted to many colleagues for valuable discussion, criticism and encouragement, especially to Prof. J. F. Danielli, Miss J. Moyle, Dr. J. M. Mitchison and to the head of this Department, Prof. M. M. Swann. It is also a pleasure to acknowledge support by grants from the Scottish Hospital Endowments Research Trust.

[1] Davies, R. E., and Ogston, A. G., *Biochem. J.*, **46**, 324 (1950).
[2] Ussing, H. H., "Adv. Enzymol.", **13**, 21 (1952).
[3] Kalckar, H. M., and Klenow, H., "Ann. Rev. Biochem.", **23**, 527 (1954).
[4] Mitchell, P., Biochem. Soc. Symposia, 16 (in the press); see *Nature*, **179**, 661 (1957).
[5] Mitchell, P., "The Nature of the Bacterial Surface", edit. by Miles, A. A., and Pirie, N. W., 55 (Blackwell, Oxford, 1949). Mitchell, P., Ph.D. thesis, Univ. Camb. (1950).
[6] Gale, E. F., and Mitchell, P., *J. Gen. Microbiol.*, **1**, 299 (1947). Gale, E. F., *Bull. Johns Hopkins Hosp.*, **83**, 119 (1948).
[7] Gale, E. F., "Adv. Protein Chem.", **8**, 285 (1953).
[8] Roberts, R. B., Abelson, P. H., Cowie, D. B., Bolton, E. T., and Britten, R. J., "Studies of Biosynthesis in *Escherichia coli*", Carnegie Inst. Pub. 607 (Kirby Lithographic Co., Washington, 1955).
[9] Britten, R. J., Roberts, R. B., and French, E. F., *Proc. U.S. Nat. Acad. Sci.*, **41**, 863 (1955). Cohen, G. N., and Rickenberg, H. V., *C.R. Acad. Sci., Paris*, **240**, 2086 (1955).
[10] Mitchell, P., and Moyle, J., *Symp. Soc. Gen. Microbiol.*, **6**, 150 (1956).
[11] Mitchell, P., and Moyle, J., *Farad. Soc. Discuss.*, **21**, 258 (1956).
[12] Rowlands, D. A., Gale, E. F., Folkes, J. P., and Marrian, D. H., *Biochem. J.*, **65**, 519 (1957).
[13] Cohen, G. N., and Rickenberg, H. V., *Ann. Inst. Pasteur*, **91**, 693 (1956).
[14] Rickenberg, H. V., Cohen, G. N., Buttin, G., and Monod, J., *Ann. Inst. Pasteur*, **91**, 829 (1956).
[15] Weibull, C., *Exp. Cell Res.*, **9**, 139 (1955).
[16] Mitchell, P., *Symp. Soc. Exp. Biol.*, **8**, 254 (1954).
[17] Mitchell, P., *J. Gen. Microbiol.*, **11**, 73 (1954).
[18] Ussing, H. H., *Nature*, **160**, 262 (1947).
[19] Axelrod, B., "Adv. Enzymol.", **17**, 159 (1956).
[20] Jonas, H., and Gourley, D. R. H., *Biochim. Biophys. Acta*, **14**, 335 (1954).
[21] Danielli, J. F., *Symp. Soc. Exp. Biol.*, **8**, 502 (1954).
[22] Prankerd, T. A. J., *Internat. Rev. Cytol.*, **5**, 279 (1956).
[23] Mitchell, P., *Farad. Soc. Discuss.*, **21**, 278 (1956).
[24] Mitchell, P., Moyle, J., and Stephen, B. (unpublished observations).
[25] Kihara, H., and Snell, E. E., *J. Biol. Chem.*, **197**, 791 (1952). Umbarger, H. E., and Brown, B., *J. Bact.*, **70**, 241 (1955).
[26] Davis, B. D., "Enzymes: Units of Biological Structure and Function", edit. by Gaebler, O. H., 509 (Academic Press, New York, 1956).
[27] Mitchell, P., and Moyle, J., *Biochem. J.*, **64**, 19*P* (1956).
[28] Storck, R. L., and Wachsman, J. T., *Biochem. Soc. Proc.* April (1957).
[29] Park, J. T., and Strominger, J. L., *Science*, **125**, 99 (1957).
[30] Racker, E., "Mechanism of Enzyme Action", edit. by McElroy, W. D., and Glass, B., 464 (Johns Hopkins Press, Baltimore, 1954).
[31] Gunsalus, I. C., "Mechanism of Enzyme Action", edit. by McElroy, W. D., and Glass, B., 525 (Johns Hopkins Press, Baltimore, 1954).
[32] Topley, W. W. C., and Wilson, G. S., "The Principles of Bacteriology and Immunity", 51 (Arnold, London, 1929).

LETTERS TO THE EDITORS

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The Units of Time and Length

SINCE the atomic standard of frequency was put into operation[1], a number of comments have been published[2–10] concerning the possibility of using the standard to define the unit of time; but two queries initially raised by Dr. G. M. Clemence[3] have not yet been fully answered.

The discussion has been somewhat obscured by the fact that some contributors regard units as abstract ideas which are invariable, and others as the practical realization of these ideas which are not invariable. All physical measurements are made in terms of the practical units, and the concept of ideal invariable units does not seem to be necessary although some physicists have found it useful. It is certainly confusing when the same name is used for both the ideal and the practical units, and in my view it is preferable to restrict the term 'unit' to those practical quantities in terms of which the results of measurements are expressed. They are chosen so that they can be regarded as constant for most purposes, which is indeed essential if they are to serve as the foundation of a reliable structure of physical measurement. But if the precision of measuring a quantity in terms of the appropriate unit is equal to or greater than that with which the unit itself can be defined, then the possibility of variations of the unit must be considered.

When this position arises, it often, but not always, means that the quantity which can be measured with the higher precision could be used for defining a more precise unit. For example, variations of the mean solar second have been established by both the atomic standard and by quartz standards; but whereas the atomic standard could be used to define the unit, quartz standards are quite unsuitable for this purpose. In a strictly formal sense, the value of a unit remains constant in that its value is, by definition, taken as unity in quantitative results. Thus as long as the mean solar second was used as the unit of time, the rates of pendulum, quartz and atomic clocks all varied in a periodic manner. The simpler assumption is that the unit is varying, and from the beginning of 1957 a new unit of time, the second of the time-scale U.T.2, has been employed; and if the correction used in deriving this new unit is valid, all these periodic variations will have disappeared. Although, therefore, the second can be regarded as a constant unit of time for almost all purposes, for the most precise measurements its constancy cannot be taken for granted, and it must be carefully labelled if experimental results are to be interpreted correctly.

The consequence of the adoption of atomic units which seems to cause physicists the most concern is the constancy of the velocity of light. This is regarded as a limitation; but a little consideration shows that it is an essential feature of any system of units incorporating the wave-length standard of length. For although the wave-length standard can be defined and used without reference to any physical laws, it is important to consider the laws governing the emission and propagation of electromagnetic waves. The quantum mechanical law of emission can be written:

$$\nu = (E_2 - E_1)/h$$

where ν is the frequency of the radiation, E_2 and E_1 are two energy-levels of the atom and h is Planck's constant; and the law of propagation is simply $v = \lambda\nu$ or, in a vacuum, $c = \lambda\nu$, where λ is the wave-length and c is the velocity of light. As there is no reason to believe that there is a close relationship between the two laws, the wave-length of the radiation is constant only if both ν and c are constant. A self-consistent system of units can therefore be obtained only by choosing the unit of time so as to maintain the constancy of these two quantities. The only way of achieving this is to use ν, the frequency of the radiation, to define the unit of time.

Practical considerations, however, make it inconvenient to adopt this ideal system, because there is at present no technique for measuring the frequency of a light-wave, and the techniques of using radio-waves, the frequencies of which can be measured, for length measurement are not yet sufficiently highly developed. The present choice would therefore be to use a radiation such as that of the cæsium line for defining the unit of time, and the radiation of a suitable light-source for defining the unit of length. The resulting system, which was suggested in principle by Drs. Huntoon and Fano[11] in 1950, is self-consistent so long as the ratio of the frequencies of the two radiations remains constant. The units of length and time are no longer independent in the proposed system, the two independent quantities being the frequency of the emitted radiation and the velocity of light. Of the three quantities concerned, any two can be given arbitrary values in order to define the units of measurement, although, of course, in practice, discontinuities in physical measurements will be avoided by choosing the 'arbitrary' values so as to preserve the existing values of the units within the accuracy with which they are known.

The second point raised by Dr. Clemence[3] is the difficulty of ensuring that two atomic clocks indicate the same time (epoch) and of ensuring continuity of operation. It has already been indicated briefly[7] that quartz clocks and astronomical measurements together can be used for this purpose; but it may be useful to discuss the problem in a little more detail. Quartz clocks directly controlled or monitored by the atomic standard provide a time-scale, in steps of 10^{-5} sec., extending over periods of years, and this scale is adequate for all physical measurements that can be envisaged. In general, only time-interval is required in such measurements, epoch being of no significance.' For astronomical measurements and for civil time, it is convenient to define epoch in relation to the position of the Earth relative to the Sun, but the precision required is relatively low and will always be limited by that of the astronomical measurements. Thus if epoch is defined as a certain number of completed revolutions of a solar body together with fraction of a revolution expressed in seconds, the precision is limited by the difficulty of determining the beginning and end of a revolution, and any small difference there may be between the fraction of a revolution as expressed in terms of the atomic or astronomical unit of time is quite negligible. Any changes in the phase of the atomically controlled quartz standard which may be necessary to synchronize atomic and astronomical time will be noted, so that a continuous record of the relationship

between the two systems will be preserved, and any interval, however long, can be expressed in terms of the atomic unit. A time system of this kind, in which interval is based on the atomic unit but epoch on astronomical measurements, has been provided by the National Physical Laboratory for the past two years. It has caused no difficulties and has already been used for measuring the variations in the period of rotation of the Earth[12].

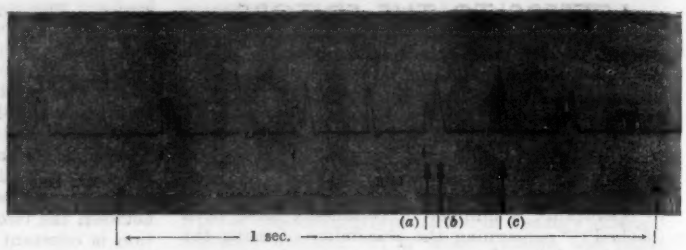

Fig. 1. High-speed record of pulses received at Slough. Time: 0916 U.T., October 18, 1956. (*a*) *E*-region forward scatter pulse; (*b*) *F*2-region and ground back-scatter pulse; (*c*) round-the-world echo.

These problems have been discussed with my colleagues, Drs. H. Barrell and L. Hartshorn and Mr. J. V. L. Parry, and the form in which my views are presented owes much to these discussions. This communication is published by permission of the Director, National Physical Laboratory.

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[1] Essen, L., and Parry, J. V. L., *Nature*, **176**, 280 (1955).
[2] Bullard, E. C., *Nature*, **176**, 282 (1955).
[3] Clemence, G. M., *Nature*, **176**, 1230 (1955).
[4] Perard, A., *Nature*, **177**, 850 (1956).
[5] Abraham, H. J. M., *Austral. J. Sci.*, **18**, 103 (1956).
[6] Clemence, G. M., *Science*, **123**, 567 (1956).
[7] Essen, L., *Nature*, **178**, 34 (1956).
[8] Dingle H., *The Observatory*, **76**, 130 (1956).
[9] Bullard, E. C., *The Observatory*, **76**, 238 (1956).
[10] Dingle, H., *The Observatory*, **76**, 239 (1956).
[11] Huntoon, R. D., and Fano, U., *Nature*, **166**, 167 (1950).
[12] Stoyko, N., *C.R. Acad. Sci., Paris*, **244**, 43 (1957).

Delayed Signals in Ionospheric Forward-scatter Communication

It has been reported[1] that long-delay multipath effects were observed when pulsed transmissions on 37 Mc./s. from Gibraltar were received in the United Kingdom during very high frequency forward-scatter propagation measurements. Delayed signals at multiples of approximately 20 msec. up to 80 msec. and traces of later components with about 130 msec. delay were detected. It was suggested that these were caused by a combination of reflexions at the *F*2 region and ground back-scatter behind the transmitting aerial, but the possibility of round-the-world propagation was discounted. The earlier delayed echoes were most probably due to the mechanism suggested, but observations at the Radio Research Station have shown that the signal with the longest delay was more likely to be due to round-the-world propagation.

Soon after the start of transmissions in March 1956, a weak pulse of intermittent nature was seen having a delay of about 140 msec. relative to the direct pulse received by *E*-region scattering. In the autumn, when *F*2 ionization was increasing, the pulse was again detected and was strong enough for its characteristics to be observed (see Fig. 1). Little distortion of the delayed pulse was apparent, showing that ground back-scatter was not involved. Directional measurements indicated that this pulse was arriving from the direction of Gibraltar and close to the great-circle path. The echo was most persistent during 0900–1030 hr. U.T., and at this time the complete great circle path was close to the twilight zone. Repeated echoes at 140 msec. intervals were occasionally seen similar to those observed at lower frequencies[2,3]. All these characteristics indicate that round-the-world propagation was occurring.

Measurements of the time delay of the pulse were made and gave a value greater than that previously reported[2] for frequencies of 10–20 Mc./s.; this suggests that a longer effective transmission path is involved at 37 Mc./s. Possible mechanisms for this type of propagation and its effect on communication by *E*-region forward scatter are being studied and a full account of the work will be given later.

The work described was carried out as part of the programme of the Radio Research Board. This communication is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

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[1] Crow, D. A., *et al.*, *Nature*, **178**, 1280 (1956).
[2] Hess, H. A., *Proc. Inst. Rad. Eng.*, **36**, 981 (1948).
[3] Humby, A. M., Minnis, C. M., and Hitchcock, R. J., *Proc. Inst. Elect. Eng.*, **102**, B, No. 4, 513 (1955).

Ionospheric Studies by the Lunar Radar Technique

Investigation of the ionosphere by the lunar echo technique is now being carried out at the Defence Research Telecommunications Establishment near Ottawa.

The transmitter consists of a klystron power-amplifier capable of delivering to the antenna better than 10 kW., in continuous operation. The exciter, which drives the power amplifier, operates at 488 Mc./s. derived by multiplication from a 1 Mc./s. crystal standard, stable to about 1 part in 10^9. The receiver is fed from a pre-amplifier which has a noise figure of 5 db. and a gain of 20 db. Local oscillator injection-frequencies are obtained from a crystal standard similar to that used at the transmitter. The receiver is a dual-conversion type with intermediate frequencies of 32 and 4 Mc./s. Synchronous detection is employed to give an audio output signal equal in frequency to the Doppler shift of the signal reflected from the Moon. An improved signal-to-noise ratio is obtained by following the Doppler shift with a narrow band-pass filter of variable centre frequency.

The transmitting antenna is a horn mounted at the focus of a 28-ft. paraboloid. The radio-frequency

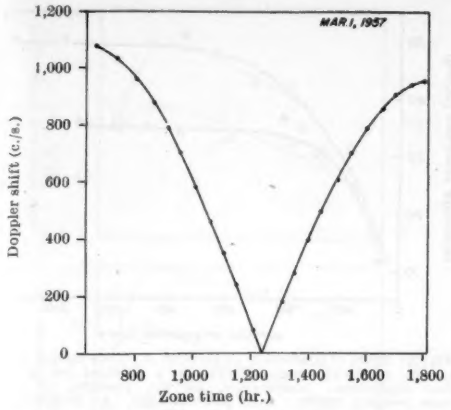

Fig. 1. Experimental measurement of the Doppler shift

feed is 3⅛ in. coaxial cable. The receiving antenna consists of orthogonal dipoles having 40 db. isolation and a reflector similar to that at the transmitter. The use of specially modified polar drive units permits continuous tracking of the Moon from moonrise to moonset.

At present, the transmitter is keyed 'on' for 2 sec. and 'off' for 4 sec., the receiver being gated 'off' while the transmitter is 'on'. On alternate 6-sec. periods the receiver is switched between the orthogonal dipoles. Lunar echoes are recorded simultaneously on magnetic tape and on a chart recorder.

Fig. 1 indicates the Doppler shift obtained experimentally for a complete lunar day on March 1, 1957. Fig. 2 shows typical lunar echoes recorded with a 40-msec. time constant. The lower trace covers a period of about two minutes, during which time the echoes were significantly different as received on the two orthogonal dipoles. The upper trace shows in more detail some of the fine structure of the echoes. The Doppler shifts are 430 and 900 c./s. for the upper and lower traces, respectively. The post-detection bandpass is approximately 4 per cent of the centre frequency.

Preliminary results indicate the presence of fading due to libration, as well as long-period Faraday rotation, both reported by other workers[1]. In addition, there appears to be a component of Faraday rotation which has a period of a minute or two. This is probably related to ionospheric irregularities. Also, there is a long-term fading not apparently accompanied by any rotation.

It is hoped to adapt the system for continuous-wave operation as well as for operation on a second frequency. Matched receivers will be used for continuous recording of the signals on both dipoles.

I acknowledge the invaluable assistance of Fred D. Green and Harold V. Serson in this project.

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[1] Kerr, F. J., Shain, C. A., and Higgins, C. S. *Nature*, **163**, 310 (1949). DeWitt, J. H., and Stodola, E. K., *Proc. Inst. Rad. Eng.*, **37**, 229 (1949). Murray, W. A. S., and Hargreaves, J. K., *Nature*, **173**, 944 (1954). Kerr, F. J., and Shain, C. A., *Proc. Inst. Rad. Eng.*, **39**, 230 (1951). Browne, I. C., Evans, J. V., Hargreaves, J. K., and Murray, W. A. S., *Proc. Phys. Soc.*, B, **69**, 901 (1956).

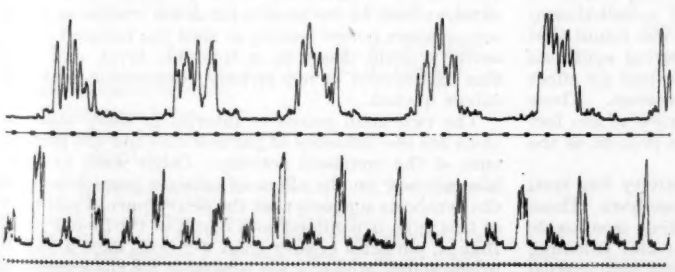

Fig. 2. Chart recording of lunar echoes

A Possible Auroral Enhancement of Infra-red Radiation emitted by Atmospheric Ozone

During the early part of this year, the nocturnal atmospheric emission in the near infra-red (to 15 microns) has been observed at College, Alaska, using a standard Perkin–Elmer single-pass monochromator with a rock-salt prism and thermocouple detector. The instrument was directed toward the southern sky, at about 20° above the horizon, giving an optical path of about four air masses.

The radiation received at 9·6 microns may be considered as due solely to ozone. Small fluctuations in the intensity of this emission are common, but on March 26, 1957, at about 11.55 p.m., an exceptionally large increase, amounting to about 18 per cent, was observed. This increase occurred immediately after the aurora had moved into the region of the sky covered by the instrument. Half an hour earlier, before the aurora had moved so far south, the ozone radiation was normal. This observation suggests that the 9·6 micron radiation may have been enhanced by the aurora, either by an increase in the amount of ozone, or in its temperature. Observations will be continued when the dark nights return. If this connexion between the aurora and radiation from the ozonosphere is confirmed, it will be additional evidence that the atmosphere is affected by the aurora at lower levels than was formerly thought likely.

It is not difficult to see how the effect could be produced. The spectrum of the aurora[1] may be assumed to extend farther into the ultra-violet than is observed from the ground, the short wave-length limit being set by ozone absorption. The Lyman series of hydrogen, for example, must be present, because the Balmer series is observed, and it is to be expected that radiation from oxygen and nitrogen of wave-length less than 3000 A. is also present. Absorption of this radiation by ozone already present could heat the ozonosphere; also some of the radiation might be effective in producing ozone. Van Allen and his collaborators have detected the presence of radiation believed to be X-rays (bremsstrahlung from auroral electrons[2]) near the auroral zone. This radiation was observed from 40 km. up, and its absorption must at least heat the atmosphere.

These relatively low-level auroral influences merit close study in view of their possible meteorological implications.

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[1] Harang, L., "The Aurorae" (Wiley and Sons, New York, 1951); Störmer, C., "The Polar Aurora" (Oxford, 1955).
[2] Van Allen, J. A., "Scientific Uses of Earth Satellites" (Univ. of Michigan Press, Ann Arbor, 1956).

Effect of Ionizing Radiation on Solid Catalysts

It has been recognized for some time that the activity of solid catalysts might be affected by ionizing radiations, and a number of workers have studied the effect of X-rays on catalysts. Clark, McGrath and Johnson[1] observed a small increase in the activity of a platinum catalyst for the oxidation of sulphur dioxide in the presence of water vapour, and Harker[2] reported an increase in the uptake of hydrogen from the gas phase by copper and palladium during irradiation. However, Emmett and Jones[3] found that the speed of reaction of hydrogen and oxygen on a platinum/asbestos catalyst was not affected by irradiation, and Gotzky and Günther[4] obtained negative results for the reaction of hydrogen and chlorine on a variety of catalysts.

Taylor[5], using cobalt-60 γ-radiation, recently reported that the activity of γ-alumina for the hydrogen/deuterium exchange reaction at − 78° C. is markedly increased by quite small doses of radiation, and that the increased activity declined over two to four days at room temperature.

During the past two years, a study of the effect of cobalt-60 γ-radiation on solid catalysts has been in progress at the Fuel Research Station, and in view of Taylor's recent results, it may be of interest to record some of our results. The study has been directed toward finding effects which will persist under the conditions required for reactions of practical interest. It is common experience that the effects of radiation in solids rapidly disappear during quite short periods at room temperature or higher. However, an effect has been found which persists for at least 300 hr. at 280° C.

The main interest in the study has been in the catalytic synthesis of hydrocarbons from carbon monoxide and hydrogen (Fischer–Tropsch process). The synthesis reaction takes place in the presence of cobalt or iron catalysts. It was found that doses of radiation up to 2×10^7 r. effected no change in the activity of the catalyst or the composition of the products when using a reduced cobalt/thoria/magnesia/kieselguhr catalyst. Also it was found that irradiation of the reacting system during synthesis at a dose-rate of about 4×10^4 r./hr. had no effect on the rate of reaction in a static system. These results are not perhaps surprising in view of the fact that about 60 per cent of the cobalt is present as the metal.

However, a marked increase in activity has been observed when using unreduced iron catalysts. These catalysts are prepared by impregnating iron oxide (mill-scale) with potassium carbonate and calcining for 4 hr. at 1,000–1,300° C. Irradiations were carried out in nitrogen on samples which had been dried by evacuation at room temperature; as soon as the irradiation was completed, the samples were transferred to the catalyst testing units in an atmosphere of nitrogen or water gas, and the testing started. The doses used were in the range $1–5 \times 10^7$ r.

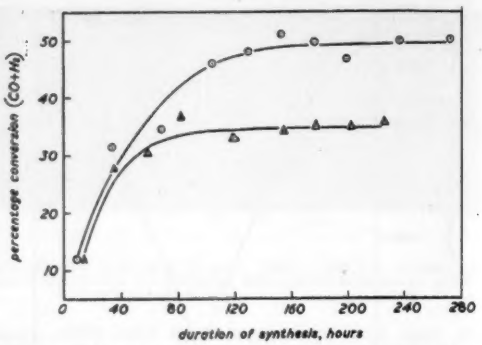

Fig. 1. Effect of irradiation on catalyst *A*. Tests carried out on 41 gm. of 72–170 mesh catalyst, in a fluidized bed system. Test conditions: temperature, 280° C.; pressure, 10 atm.; space velocity, 986/hr.; inlet gas, water-gas. ▲, Unirradiated; ○, dose $3 \cdot 6 \times 10^7$ r.

When particles in the size-range 100–200μ were used for the synthesis in a fluidized system at 10 atm. and 280° C., increases of 10–40 per cent were observed in the rate of conversion of $(CO + H_2)$ as a result of irradiation. This effect was observed with two different catalysts, prepared from different mill-scales and calcined at different temperatures, and in a total of seven experiments with irradiated catalysts, five comparison tests being carried out with unirradiated samples. The duration of the tests varied from 48 to 300 hr., and the high activity of the irradiated samples remained until the end of the tests in all cases. Fig. 1 shows activity plotted against time for a pair of experiments with one catalyst; similar graphs were obtained for the other catalyst tested.

Particles in the size range 0·2–5μ were tested in a system in which the catalyst was suspended in a high-boiling fraction of synthesis product through which synthesis gas was passed. In these experiments, it was possible to measure the yield of products as well as the gas conversions. The results of tests with one irradiated and two control samples are shown in Fig. 2. The increase in activity is larger than that observed using particles of 100–200μ of the same catalyst, being in the range 40–60 per cent.

No increase in activity was observed when catalyst particles in the size range 400–600μ were irradiated with a γ-dose of $4 \cdot 8 \times 10^7$ r., or when large particles (1·2–2·4 mm.) were irradiated in the reactor BEPO (10^{13} n./cm.^{2} + associated γ-dose). The pile-irradiated catalyst had to be stored for some weeks at room temperature before testing so that the induced radioactivity could decay to a tolerable level, and thus this experiment is not strictly comparable with the others quoted.

The two main points of interest in these observations are the influence of particle-size and the persistence of the increased activity. Other work in these laboratories[6] on the effect of catalyst particle-size on the synthesis suggests that the active part of catalysts of this type is confined to a depth of 0·075–0·1 mm., that is, particles greater than 0·2 mm. have a region in the centre which is not available for the synthesis. It is interesting to note that the increase in activity

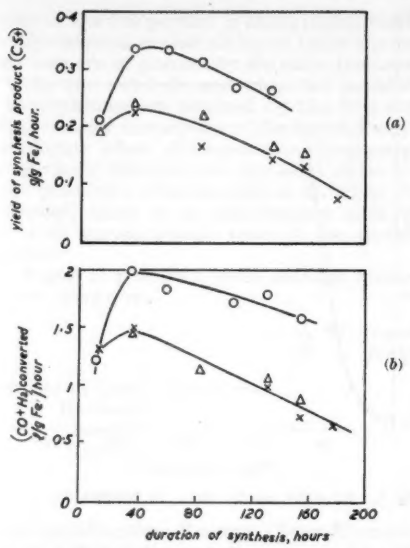

Fig. 2. Effect of irradiation on catalyst *B*. Tests carried out on 50 gm. of finely ground catalyst suspended in a paraffin wax medium. Test conditions: temperature, 285° C.; pressure, 20 atm.; space velocity, approx. 200/hr. based on slurry volume; inlet gas, water-gas. ×, △, Unirradiated; ○, dose $3{\cdot}6 \times 10^9$ r.

induced by radiation only becomes apparent when the catalyst granules are less than this critical size.

From a study of the activity/time graphs, it is evident that the irradiated catalyst is not significantly more active than the untreated catalyst during the first few hours under synthesis conditions. It is thus unlikely that the primary changes produced by the radiation (electronic excitation, lattice imperfections) are directly responsible for the increased activity.

It appears rather that irradiation produces changes which facilitate and extend the 'conditioning' of the catalyst (partial reduction and the formation of iron carbides), which always takes place during the initial period of treatment under synthesis conditions, and which is accompanied by a marked rise in activity. This view is supported by the fact that irradiation does not increase the activity of these catalysts (100–200μ) for the decomposition of hexyl alcohol in an atmosphere of nitrogen.

Work is now in progress to examine further the nature of the changes produced and the reasons for the observed increase in the activity of these catalysts.

This work forms part of the programme of the Fuel Research Board of the Department of Scientific and Industrial Research, and this report is published by permission of the Acting Director of Fuel Research.

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[1] Clark, G. L., McGrath, P. C., and Johnson, M. C., *Proc. U.S. Nat. Acad. Sci.*, **11**, 646 (1925).
[2] Harker, G., *J. Soc. Chem. Indust.*, **51**, 314 (1932).
[3] Emmett, P. H., and Jones, E. J., *J. Phys. Chem.*, **34**, 1102 (1930).
[4] Gotzky, S., and Günther, P., *Z. phys. Chem.*, B, **26**, 373 (1934).
[5] Taylor, E. H., and Kohn, H. W., *J. Amer. Chem. Soc.*, **79**, 252 (1957).
[6] "Fuel Research 1952", 13.

Molecular Weight Determination in Polyethylene Terephthalate

It has hitherto proved difficult to obtain molecular weight determinations on polyethylene terephthalate because normal values (approximately 20,000) fall in an experimentally difficult region. Recently, however, a method based on deuteration of the end groups has been developed for determining the number average molecular weight of this polymer.

Polyethylene terephthalate is a linear polyester in which the end-groups (shown by infra-red[1] and chemical analysis) are —OH and —COOH groups. Successive immersions of the polymer in fresh heavy water (D_2O) cause these groups to be replaced quantitatively by —OD and —COOD. If the dry polymer is then burnt, the water produced can be analysed for deuterium[2] and the total number of end-groups calculated. The total end-group content of a series of samples was found in this way and in each case the intensities of the —OH and —COOH infra-red absorptions at 3μ [1] measured. From these results a calibration method was devised for determining the total number of end-groups in any sample of polyethylene terephthalate directly from the intensities of the infra-red absorptions. Hence the number average molecular weight can be determined, no cyclic structures being present apart from very small amounts of a cyclic trimer[3].

Measurements have been made on a series of polyethylene terephthalate samples of different intrinsic viscosity. The intrinsic viscosities were measured with an Ostwald viscometer using a 1 per cent solution in *o*-chlorphenol. The results are shown in Fig. 1. It can be seen that there is a reasonably linear relationship between the intrinsic viscosity and the number average molecular weight $\bar{M}_n$. Assuming that $[\eta] = k\bar{M}_n{}^{\alpha}$, a regression analysis shows that $\alpha = 0{\cdot}77 \pm 0{\cdot}09$ and $k = (3{\cdot}0 \pm 1{\cdot}2) \times 10^{-4}$. Full details of this work are being published elsewhere.

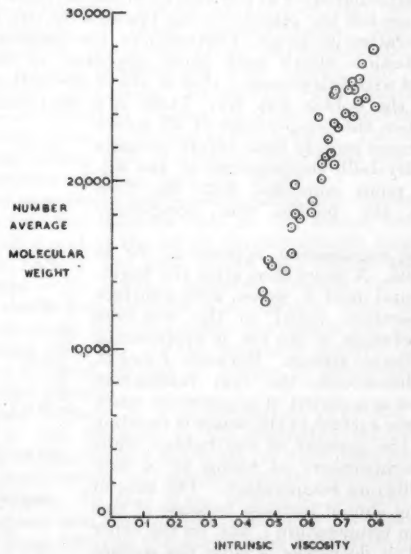

Fig. 1. Graph illustrating relationship between number average molecular weight and intrinsic viscosity for polyethylene terephthalate

I am indebted to Dr. H. R. C. Pratt, of the Atomic Energy Research Establishment, Harwell, for suggesting the combustion technique.

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[1] Patterson, D., and Ward, I. M., *Trans. Farad. Soc.*, **53**, 291 (1957).
[2] Gaunt, J., *Analyst*, **29**, 580 (1954).
[3] Rose, J. D., *et al.*, *J. Poly. Sci.*, **13**, 406 (1954).

Mechanism of Drying of Thick Porous Bodies during the Falling-Rate Period

Experiments carried out in this Department suggest that the mechanisms of drying in the constant and falling-rate periods are essentially the same except in one particular respect, namely, the value of the wet-bulb temperature of the air into which drying takes place.

Fig. 1 shows the usual constant and falling rates of drying obtained on a thick, porous bobbin of woven 'Terylene' with fairly large voids. Fig. 2 shows the temperature attained by four different layers within the bobbin at different times.

It will be seen that initially all layers approached the wet-bulb temperature of the air of 26° C. approximately. At point *A*, which coincided with the end of the constant-rate period, the temperature of the surface layer rose steeply to the dry-bulb temperature of the air. All other layers rose to another plateau of temperature, a 'pseudo wet-bulb temperature', *BCD*. The temperatures of layers of increasing depth within the bobbin left this plateau at different times, as shown at *B*, *C* and *D*. From the weight of the bobbin it appeared reasonable to conclude that the free surface of the water had just receded beyond the depth of the particular layer at the time at which the layer temperature left the plateau to rise towards the dry-bulb temperature of the air. Furthermore, the temperature distribution above each layer appeared to be in accord with this picture; that is, above this particular layer the bobbin was dry. There is a final kink at *E*, when the temperature of all layers rose more steeply than before towards the dry-bulb temperature of the air. This point coincided with the time when the bobbin was 'completely dry'.

The explanation appears to be as follows. A short time after the beginning and until *A*, water, with a surface temperature equal to the wet-bulb temperature of the air, is evaporating into the air stream. Between *A* and *B*, or thereabout, the first falling-rate period is a period of adjustment when the free surface of the water is receding into the interior of the bobbin while its temperature is rising to a new equilibrium temperature. The rate of drying should increase because of this rise in temperature; but, on the other hand, it decreases because the surface of the water is receding from contact with a moving air stream into contact with a stationary air pocket within the bobbin. The net result is a decrease. This period is short, and equilibrium is reached after point *B*. The surface of the water is now at the pseudo wet-bulb temperature. This temperature is the result of the equality of heat input due to the temperature gradient and heat output due to evaporation in precisely the same way that the ordinary wet-bulb temperature is attained in the presence of a moving air stream. It is in fact a wet-bulb temperature in stagnant air. As evaporation into stagnant air is less than that into moving air for the same surface temperature, both the heat input required by the surface and the drop from the dry-bulb temperature are smaller than before. Accordingly, the pseudo wet-bulb temperature is higher than the ordinary wet-bulb temperature.

As the free surface recedes beyond each layer, the temperature of the layer rises to a value intermediate between the dry-bulb temperature of the air and the pseudo wet-bulb temperature in accordance with the principles of heat conduction. The thermal con-

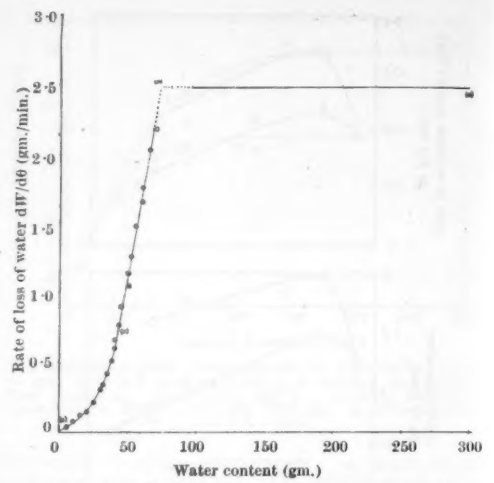

Fig. 1. Air speed, 435 cm./sec.; air temperature, 50·9° C.

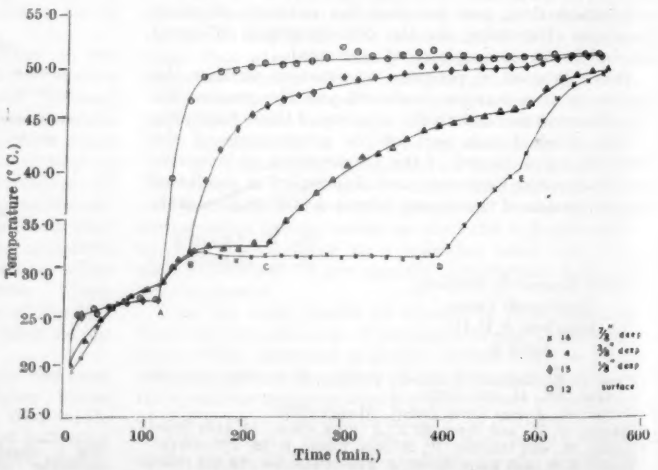

Fig. 2. Air speed, 435 cm./sec.; air temperature, 50·9° C.

ductivity of the wet portion is much higher than that of the dry material, so that all layers below the surface of the water are at practically the same temperature, both when the wet-bulb and when the pseudo wet-bulb temperatures are attained by the free surface. Finally, when the free surface of the liquid disappears, the stabilizing effect of evaporation disappears and the whole body behaves as a dry solid under a temperature gradient. This happens at E, when, it will be observed, there is a simultaneous kink in all temperature curves except that of the surface of the bobbin.

It is hoped to publish a more detailed account of this work elsewhere.

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Para-Localization Energy (Free-Electron Molecular-Orbital) and Polarographic Half-Wave Potential of some Polynuclear Hydrocarbons

In a recent communication, Fernandez-Alonso and Domingo[1] have reported some numerical disagreements in their *para*-localization energy calculation with those of Basu[2]. In Fernandez-Alonso and Domingo's calculation the box dimension for ethylene was taken as equal to one bond-length (as well as half bond-length) more at each end. In Basu's calculation the box dimension was taken to be equal to the length of C—C double bond.

In the conventional free-electron approximation, the length of the box is extended half a bond-length at each end for aliphatic conjugated compounds in order to get agreement with their absorption spectra. This assumption, however, is not valid for ethylene, since this gives a resonance energy of benzene which is six times too high. This point has been discussed by Basu[3,4] in two subsequent papers. There is no physical reason for extending the box dimension more than half a bond-length in the case of ethylene alone. Because of this uncertainty the box dimension was not adjusted in Basu's calculation. The conclusion arrived at by Basu is necessarily limited by the basic assumptions made, and is not expected to be valid if the initial conditions are changed.

The *para*-localization energy of naphthalene recorded as 4·00 is due to a typographical error (the value refers to benzene)[5]. A fairly linear plot is obtained with *para*-localization energy values uncorrected for overlap. It is only an average linear plot that is expected in this type of calculation. In the calculation of *para*-localization energy with two electrons fixed on two carbon atoms, it is not known what changes are introduced in the bond-lengths of the rest of the molecule. So the introduction of overlap correction alone in this type of calculation is not very well justified. This is the reason why $E_{1/2}$ was not plotted against overlap corrected *para*-localization energy, although the values are given in the same table of Brown[4] from which Basu and Bhattacharya's data were collected, and although in the first free-electron calculation Basu[2] compared his values with the overlap corrected values of Brown.

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[1] Fernandez-Alonso and Domingo, *Nature*, **179**, 829 (1957).
[2] Basu, *J. Chem. Phys.*, **23**, 1548 (1955).
[3] Basu, *Trans. Farad. Soc.*, **52**, 6, 1175 (1956).
[4] Brown, *J. Chem. Soc.*, 691 (1950).
[5] Basu and Bhattacharya, *J. Chem. Phys.*, **25**, 596 (1956).

Inactivation of Antihæmophilic Globulin by Thrombin

Normal plasma defibrinated by addition of 'Thrombin Topical' (Parke Davis), 5 units per ml., loses its antihæmophilic activity[1]. In the experiments described here, each of the reagents in the thromboplastin generation test[2] (platelets, serum, plasma adsorbed with barium sulphate and $M/40$ calcium chloride) in turn was incubated at 37° C., for periods of three minutes and longer, in the presence of thrombin, and then used in the thromboplastin-generating mixture. Initially 'Thrombin Topical' was used, generally in concentrations of the order of 0·15 unit per ml. In every case, the expected acceleration of thromboplastin generation was observed[2]. However, while this treatment of the platelets, serum and calcium had no effect on the potency of the thromboplastin eventually generated, the 'thrombinized' and pre-incubated adsorbed plasma consistently yielded a much weaker thromboplastin than the control. Thus, pretreatment of the adsorbed plasma with 'Thrombin Topical' converted a normal thromboplastin generation curve into one resembling that found in hæmophilia. This effect was found to be irreversible and unaffected by dilution.

Since adsorbed plasma contributes two essential constituents of blood thromboplastin, factor V (Ac-globulin, pro-accelerin) and antihæmophilic globulin, further experiments were carried out using mixtures of normal, hæmophilic and factor V-deficient adsorbed plasma, untreated or pretreated with thrombin, in various combinations. The results showed clearly that the factor inactivated was antihæmophilic globulin and not factor V.

The experiment was repeated using very fresh serum (at most five minutes old) as the source both of thrombin and of the serum thromboplastin constituents; that is, the fresh serum was diluted and incubated with normal adsorbed plasma for three minutes before platelets and calcium were added. The resulting thromboplastin generation was greatly impaired (Fig. 1). As the thrombin activity of the serum declined, so did its ability to inactivate the adsorbed plasma.

When heparin in a concentration of 0·075 unit per ml. was included in the incubated mixture of adsorbed plasma and thrombin (or very fresh serum), the inactivation of antihæmophilic globulin was prevented. In this case, evidently, heparin was acting as a true antithrombic agent in a concentration too low to prevent thromboplastin formation (0·025 unit per ml. in the final mixture).

These findings support Alexander's suggestion that the disappearance of antihæmophilic globulin during

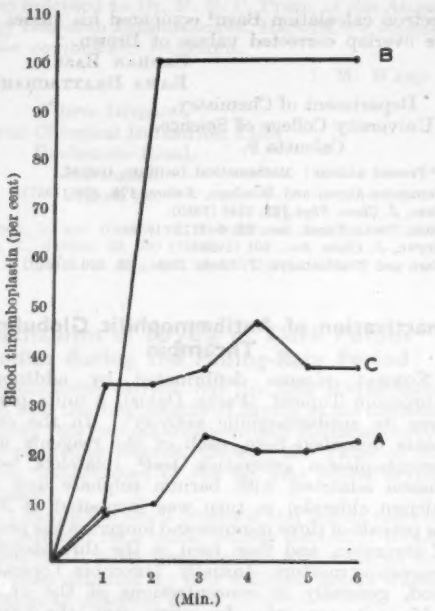

Fig. 1. Thromboplastin generated from normal platelets mixed with: *A*, normal adsorbed plasma pre-incubated for 3 min. with normal, very fresh serum; *B*, same as *A*, but mixture recalcified without pre-incubation; *C*, same as *A*, serum having stood 20 min.

clotting is caused by thrombin. Indeed, the concentration of thrombin was too low, in all the above experiments, to affect any other clotting factor, including fibrinogen. This action of thrombin may have a physiological significance meriting further investigation.

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[1] Alexander, B., Goldstein, R., Rich, L., Le Bolloc'h, A. G., Diamond, L. K., and Borges, W., *Blood*, **9**, 9, 843 (1954).
[2] Biggs, R., Douglas, A. S., and Macfarlane, R. G., *J. Physiol.*, **119**, 89 (1953). Biggs, R., and Douglas, A. S., *J. Clin. Path.*, **6**, 1, 23 (1953).

Insensitivity of Chicken Cholinesterase to Specific Inhibitors of True- and Pseudo-Enzyme

The classification of cholinesterase as pseudo- or true-enzyme does not necessarily imply that the components of each group have identical properties. Experimental evidence has been given suggesting the different sensitivity to inhibitors of the enzymes belonging to the same group[1,2].

While we were looking for further experimental support for this evidence, we studied the sensitivity of the most commonly employed enzymatic preparations to three characteristic inhibitors of cholinesterase: eucupine (*iso*amylhydrocupreine hydrochloride), physostigmine (salicylate) and *C.T.*3318 (*bis*(piperidinomethyl coumaranyl-5)ketone diiodomethylate). It has been demonstrated that eucupine is a preferential inhibitor of pseudo-cholinesterase[3], whereas *C.T.*3318 is a selective inhibitor of true-cholinesterase[3,4]. Cholinesterase activity was evaluated titrimetrically[5]. Sera were diluted with saline until they were able to destroy approximately one-third of substrate in 3 hr. at 37° C. Brain preparations were obtained from the whole brain of small animals or from basal nuclei of big animals, grinding the tissues with saline. The emulsions so obtained were diluted until destruction of one-half of the substrate occurred in 3 hr. at 37° C.

Table 1. 50 per cent Inhibiting Concentrations of Certain Drugs on Crude Cholinesterase Preparations of Different Biological Origin

Enzymic preparation	Molar concentrations of inhibitors		
	C.T. 3318	Eucupine	Physostigmine
Blood sera:			
Horse	1×10^{-6}	$0{\cdot}16 \times 10^{-6}$	$0{\cdot}9 \times 10^{-6}$
Man	$1{\cdot}3 \times 10^{-6}$	$0{\cdot}42 \times 10^{-5}$	$0{\cdot}8 \times 10^{-6}$
Hog	$1{\cdot}3 \times 10^{-6}$	—	—
Rabbit	$0{\cdot}65 \times 10^{-7}$	$0{\cdot}84 \times 10^{-5}$	$0{\cdot}53 \times 10^{-6}$
Chicken	$>1{\cdot}3 \times 10^{-5}$	$>0{\cdot}7 \times 10^{-4}$	$0{\cdot}24 \times 10^{-5}$
Duck	$>1{\cdot}3 \times 10^{-5}$	$>0{\cdot}7 \times 10^{-4}$	$0{\cdot}67 \times 10^{-7}$
Pigeon	$>1{\cdot}3 \times 10^{-5}$	$>0{\cdot}7 \times 10^{-4}$	$0{\cdot}1 \times 10^{-7}$
Guinea pig	$0{\cdot}54 \times 10^{-5}$	$>0{\cdot}7 \times 10^{-4}$	$0{\cdot}16 \times 10^{-6}$
Rat	$>1{\cdot}3 \times 10^{-6}$	$>0{\cdot}7 \times 10^{-4}$	$0{\cdot}24 \times 10^{-5}$
Dog	$0{\cdot}34 \times 10^{-5}$	$>0{\cdot}7 \times 10^{-4}$	$0{\cdot}38 \times 10^{-6}$
Brains:			
Horse	$0{\cdot}27 \times 10^{-7}$	$>0{\cdot}7 \times 10^{-4}$	$0{\cdot}43 \times 10^{-5}$
Hog	$0{\cdot}3 \times 10^{-7}$	$0{\cdot}32 \times 10^{-4}$	$0{\cdot}24 \times 10^{-6}$
Rabbit	$0{\cdot}65 \times 10^{-7}$	$0{\cdot}52 \times 10^{-4}$	$0{\cdot}24 \times 10^{-5}$
Chicken	$>1{\cdot}3 \times 10^{-5}$	$>0{\cdot}7 \times 10^{-4}$	$0{\cdot}13 \times 10^{-5}$
Duck	$>1{\cdot}3 \times 10^{-6}$	$>0{\cdot}7 \times 10^{-4}$	$0{\cdot}48 \times 10^{-6}$
Pigeon	$>1{\cdot}3 \times 10^{-5}$	$>0{\cdot}7 \times 10^{-4}$	$0{\cdot}15 \times 10^{-5}$
Guinea pig	$0{\cdot}65 \times 10^{-7}$	$>0{\cdot}7 \times 10^{-4}$	$0{\cdot}53 \times 10^{-6}$
Rat	$1{\cdot}3 \times 10^{-6}$	$0{\cdot}23 \times 10^{-4}$	$0{\cdot}6 \times 10^{-5}$
Dog	$0{\cdot}17 \times 10^{-7}$	$>0{\cdot}7 \times 10^{-4}$	$0{\cdot}24 \times 10^{-5}$

The results given in Table 1 show the 50 per cent inhibiting concentrations of the drugs. These indicate that the cholinesterase activity of chicken's, duck's and pigeon's blood serum and brain and that of rat's blood serum is scarcely affected by either eucupine or *C.T.*3318. This is not a result of general insensitivity of chicken enzyme to all inhibitors; for the enzyme is inhibited by physostigmine. Moreover, sensitivity to inhibitors is not conditioned by a particular substrate; all the above-mentioned peculiarities persist when acetylcholine is substituted for acetyl-β-methylcholine as substrate.

Because it was possible that the presence of an antagonist could be responsible for the insensitivity of chicken cholinesterase to *C.T.*3318, in Table 2 are given the results of an experiment in which I used mixed rabbit's and chicken's blood sera; it is apparent that only the rabbit's enzyme has been antagonized. Therefore we can assume that the enzyme(s) found in the avian tissues used, like those of rat's tissues, differs as regards sensitivity to eucupine and *C.T.*3318 from classical pseudo- and true-cholinesterase. It is clear from these results that crude preparations of

Table 2. Sensitivity of Rabbit's Blood Serum Cholinesterase to *C.T.*3318 in Presence of Chicken Blood Serum

Source and dilution of sera	Concentration of inhibitor (*M*)	Acetylcholine destroyed (mgm.)	Inhibition (per cent)
Rabbit 1/60	—	3·97	—
"	$1{\cdot}3 \times 10^{-7}$	0·72	82
Chicken 1/60	—	3·07	—
"	$0{\cdot}54 \times 10^{-4}$	3·10	0
Rabbit 1/60 + chicken 1/60	—	5·65	—
"	$1{\cdot}3 \times 10^{-7}$	3·25	44
Rabbit 1/20	—	7·23	—
"	$1{\cdot}3 \times 10^{-7}$	1·53	79
Chicken 1/20	—	5·87	—
"	$0{\cdot}54 \times 10^{-4}$	5·75	3

cholinesterase differ quantitatively very much in their sensitivity to inhibitors, independently from their classification as true- or pseudo-cholinesterase.

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[1] Costa, E., and Murtas, L., *Arch. Int. Pharmacodyn.*, **94**, 446 (1953).
[2] Paulesu, F., *Arch. Int. Pharmacodyn.*, **105**, 366 (1956).
[3] Zamboni, P., and Ferrari, W., *Boll. soc. med. chir. Modena*, **45**, 435 (1945).
[4] Jacob, J., *Arch. Int. Pharmacodyn.*, **101**, 446 (1955).
[5] Ferrari, W., *Boll. soc. med. chir. Modena*, **45**, 422 (1945).

Effect of Contrasted Planes of Nutrition on the Carcass Composition of the East African Dwarf Goat

THE classic studies of Hammond[1] on the mutton qualities of sheep initiated a great volume of work on the problems associated with the production of high-quality meat. The chief technique used in this field has been that of 'quantitative growth analysis'. By this means, changes due to different genetic factors between breeds within a species[1,2] and changes due to different patterns of growth have been studied, and the results interpreted in terms of the theories of allometric and heterogenic growth and centripetal development first postulated by Brody[4] and Huxley[5].

The majority of past experiments has been conducted on a basis of quantitative analysis of carcass composition of animals from different treatments slaughtered at equal live-weights. Large and statistically significant differences between the composition of high- and low-plane nutrition wet carcasses have been found.

A series of replicated experiments has recently been carried out at the Serere Experiment Station, Uganda, on the effect of plane of nutrition on the goat, and the material has been examined on a basis of slaughtering in a manner such that the mean dead-weights were equal after all dissectable fat had been removed. Two dissection stages were employed, the first at 16-lb. dissectable fatless dead-weight (point of inflexion of the exponential growth curve) and the second at 30-lb. dissectable fatless dead-weight (mean weight at sexual maturity). Three goats selected at random from each treatment and each sex were dissected at each stage.

Table 1. PERCENTAGE COMPOSITION OF THE GOAT CARCASS MINUS DISSECTABLE FAT ON A WET-WEIGHT BASIS AT THE 16-LB. STAGE

Tissue	Sig. of sex diff.	Sex	High	Low	Mean	Sig. of treatment diff.
Muscle	n.s.	Male	48·7	44·7	46·7	$\alpha = 0{\cdot}01$
		Female	49·2	45·7	47·4	
Bone	n.s.	Male	23·1	23·5	23·3	n.s.
		Female	22·0	23·2	22·6	
Skin	n.s.	Male	13·5	14·2	13·8	n.s.
		Female	13·4	13·9	13·7	
Alimentary canal	n.s.	Male	6·1	8·9	7·5	$\alpha = 0{\cdot}05$
		Female	6·3	9·5	7·9	
Visceral organs	n.s.	Male	7·5	7·6	7·6	n.s.
		Female	8·1	7·1	7·6	
Urino-genitals	—	Male	1·14	1·10	1·12	n.s.
		Female	1·01	0·63	0·82	

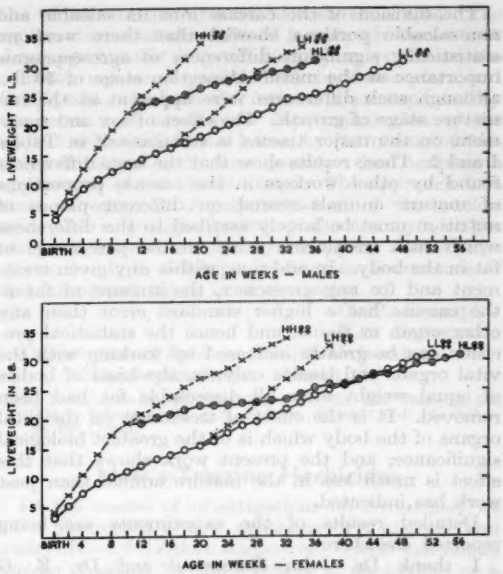

Fig. 1. Effect of plane of nutrition on growth curves of kids

The overall picture was one of marked similarity in carcass composition between the four treatments employed, high–high, low–low, high–low, and low–high planes of nutrition. The difference in the weight of muscle, and the small differences demonstrated in the weights of the rumen, reticulum, omasum, abomasum, heart, pancreas, kidney, spleen and thymus were only statistically significant at the 16-lb. stage when the heterogenic changes in these organs were most pronounced. The only organs to demonstrate statistical differences between treatments at the 30-lb. stage were the liver and the male gonads. Differences were also found in certain bone measurements but not in bone-weights. The extent of the large treatment differences on the growth-rates of the experimental kids can be seen in Fig. 1.

Table 2. PERCENTAGE COMPOSITION OF THE GOAT CARCASS MINUS DISSECTABLE FAT ON A WET-WEIGHT BASIS AT THE 30-LB. STAGE

Tissue	Sig. of sex diff.	Sex	High–high	High–low	Low–low	Low–high	Mean	Sig. of treatment diff.
Muscle	$\alpha = 0{\cdot}001$	Male	51·3	50·4	49·2	49·8	50·1	n.s.
		Female	51·5	52·8	51·4	52·7	52·1	
Bone	$\alpha = 0{\cdot}001$	Male	20·2	21·3	20·4	20·0	20·5	n.s.
		Female	19·4	18·5	19·5	18·4	19·0	
Skin	$\alpha = 0{\cdot}01$	Male	12·4	12·1	12·7	12·3	12·3	n.s.
		Female	11·8	12·0	12·2	12·4	12·0	
Alimentary canal	$\alpha = 0{\cdot}01$	Male	7·7	9·2	8·9	8·5	8·6	n.s.
		Female	9·3	9·0	8·4	8·1	8·7	
Viscera	n.s.	Male	7·2	5·8	6·9	7·5	6·9	$\alpha = 0{\cdot}05$
		Female	7·2	7·0	7·5	7·5	7·3	
Urino-genitals	—	Male	1·17	1·23	1·91	1·88	1·55	$\alpha = 0{\cdot}01$
		Female	0·78	0·74	0·95	0·94	0·85	

The division of the carcass into its saleable and non-saleable portions showed that there were no statistically significant differences of agro-economic importance at the mature dissection stage of 30 lb., although such differences were apparent at the immature stage of growth. The effect of sex and treatment on the major tissues is summarized in Tables 1 and 2. These results show that the large differences found by other workers in the carcass proportions of mature animals reared on different planes of nutrition must be largely ascribed to the differences which such treatments exert on the percentage of fat in the body. In addition, within any given treatment and for any given sex, the amount of fat in the carcass has a higher standard error than any other organ or tissue, and hence the statistical precision can be greatly increased by working with the vital organs and tissues only, on the basis of bodies of equal weight after all dissectable fat had been removed. It is the effect of treatment on the vital organs of the body which is of the greatest biological significance, and the present work shows that this effect is much less in the mature animal than past work has indicated.

Detailed results of the experiments are being reported elsewhere.

I thank Dr. John Hammond and Dr. E. G Holmes for their interest and advice throughout the course of this work, and the Makerere College Research Grants Committee for financing the project.

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[1] Hammond, J., "Growth and Development of the Mutton Qualities in Sheep" (Edinburgh, 1932).
[2] Pálsson, H., *J. Agric. Sci.*, **30**, 1 (1940).
[3] McMeekan, C. P., *J. Agric. Sci.*, **30**, 276 (1940); **31**, 1 (1941). Pálsson, H., and Verges, J. H., *ibid.*, **42**, 1 (1952). Wilson, P. N., *ibid.*, **42**, 309 (1952); **44**, 67 (1954); **45**, 110 (1954).
[4] Brody, S., Res. Bull. Mo. Agric. Exp. Sta., No. 97 (1927).
[5] Huxley, J. S., "Problems of Relative Growth" (London, 1932).

Temperature Effects in Mammalian Nerve Regeneration

Many attempts have been made by the use of various drugs and hormones and by electrical stimulations to influence the rate at which mammalian nerve fibres regenerate after injury. None of these has been successful. It has, however, recently been shown that in poikilothermic animals such as the frog[1] and the lizard[2], nerve regeneration following upon injury is greatly affected by the temperature of the environment in which the animals are kept.

In 1908 Dieneka[3] investigated the effect of temperature upon the early stages of axonal regeneration in a mammal; he concluded that regeneration in animals kept at 30° C. had progressed in three days to a stage reached only after seven to eight days in others kept at 12–14° C. His animals (rabbits) were kept no longer than twelve days following operation, and he was unable to state, therefore, whether the effect of temperature extended beyond the preliminary stages of axonal outgrowth.

Experiments have been carried out on the ventral nerve in the tail of the rat which supplies both the skin and the short intervertebral muscles. It is obvious to the touch that the rat's scaly and almost hairless tail is considerably affected by the temperature of its surroundings, and it has been shown by Huggins, Blocksom and Norman[4] that temperatures here, even within the vertebral bodies, may be considerably below that of the peritoneal cavity. The nerve was crushed aseptically under ether anæsthesia and the animals kept afterwards for various periods in either a cold room at 2–2·5° C. or in a normally warmed room at 18–21° C.

In animals kept at 2–2·5° C., no normal axons could be seen after ten days, and although a few myelin sheaths appeared normal over full internodal lengths, most were represented by strings of vacuoles or 'digestion chambers'. After twenty-two days, all myelin sheaths as well as axons had degenerated, and up to thirty-five days (Fig. 1) no evidence of the presence of regenerating fibres could be found.

In animals kept for ten days at 18–21° C. myelin sheath degeneration was complete, as was axonal degeneration in the more distal part of the stump. But a large number of fine fibres, presumably regenerating axons, were present immediately distal to the crush, lying in the Schwann tubes together with Schwann cells and the debris from the original axons. In animals kept for twenty-one days at the same temperature, only scattered droplets of degenerated myelin were found, and in the first and second centimetres below the level of the crush, fine lightly myelinated fibres were present; fine axons (unmyelinated) extended at least 7 cm. below the crush. In Fig. 2 similar lightly myelinated fibres from an animal in which the nerve had been crushed thirty-five days before death are shown. The condition of the nerve contrasts strongly with that from an animal kept for the same period at 2–2·5° C. (Fig. 1). After forty-eight days, myelination was found as far as 6 cm. below the crush level.

There seemed to be no doubt that the fibres which were found subsequent to crushing in animals kept at 18–21° C. were regenerating axons, in many of which remyelination was fairly advanced. This was confirmed by measurements of internodal lengths. All internodal lengths were short and relatively uniform as compared with those of fibres from the normal nerve. Vizozo and Young[5] have shown that short and uniform internodal lengths are characteristic of regenerating fibres, and fibres showing nodes of any kind were absent in animals kept in an environmental temperature of about 2° C.

These experiments show that regeneration in a mammalian nerve can be completely inhibited by an environmental temperature near freezing point for at least thirty-five days, although by that time all fibres show advanced degenerative changes: at environmental temperatures near 20° C., regeneration proceeds rapidly. It is not yet known what temperature may be optimal for this process.

It is perhaps relevant that Barcroft and Edholm[6] have recorded temperatures in the deep muscles of the limbs of man and have shown that these may be as much as 6° C. below rectal temperature after exposure to cool air, and as much as 17–18° C. below rectal temperature after exposure to cold water. Taken in conjunction with the present findings, this suggests that environmental temperatures may be of considerable general significance in affecting the rate of recovery after nerve injury.

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[1] Lubinska, L., and Olekiewicz, M., *Acta Biol. Exp. Varsovie*, **15**, 125 (1950).

[2] Gamble, H. J., Goldby, F., and Smith, G. M. R., *Nature*, **179**, 527 (1957).

[3] Dieneka, D., *Folia Neurobiol.*, **2**, 13 (1908).

[4] Huggins, C., Blocksom, B. H., and Norman, W. J., *Amer. J. Physiol.*, **115**, 395 (1936).

[5] Vizozo, A. D., and Young, J. Z., *J. Anat., Lond.*, **82**, 110 (1948).

[6] Barcroft, H., and Edholm, O. G., *J. Physiol.*, **104**, 366 (1946).

Lampbrush Chromosomes in Insects

The lampbrush chromosomes have been described in the male germ-cells of Orthoptera[1] and more widely in vertebrate eggs. Recently, in this laboratory also, these have been observed in the male germ-cells of not only the short-horned grasshoppers but also the gryllids. Our preparations were made after excellent fixation in Sanfelice and Bouin–Allen fluids, and these were stained with 0·5 per cent iron hæmatoxylin.

Apart from their morphology, the appearance of lampbrush chromosomes, in these insects, is correlated with the growth of the auxocyte. The premeiotic resting cell enters the leptotene stage directly without any significant growth in size. During pachytene, the cell enters the growth period and simultaneously the autosomal bivalents assume the lampbrush form, which persists until late diakinesis, when the cell has grown to its full size. In the normal mitotic cycle, the growth of the cell, which usually takes place in the resting period, is accompanied by practically the complete depolymerization of the nucleic acids, with the despiralization of the chromonemata. The lampbrush appearance of the chromosomes in the germ-cells of these insects may be physiologically correlated with the cellular growth and depolymerization, unaccompanied, however, by the complete suppression of the progressive meiotic changes in the chromosomes. The same is, perhaps, true of the oocytes.

The diffused or confused stage of Heteroptera, which usually interrupts the diplotene stage at its very beginning, may be regarded as representing a still further step. Similarly, the complete 'resting' condition of the diffused nucleus in most heteropterans represents the growth of the cell with complete depolymerization of the nucleic acids, unaccompanied by the complete suppression of the progressive meiotic changes in the autosomes. Consequently, as they reappear out of the confused stage, they have already undergone a good deal of contraction, with the terminalization of most of their chiasmata. The representation of the diffused lampbrush elements in some pyrrhocorid bugs studied by us points to the common nature of growth both in Heteroptera and Orthoptera, which, in the former, is accompanied by the more or less complete depolymerization of the nucleic acids and, in the latter, by its incomplete depolymerization and consequently the lampbrush appearance of the chromosomes. The approach to a state of complete depolymerization of the nucleic acids and very slight growth of the auxocyte at the early diplotene in the grasshopper, *Pœcilocerus pictus*, result in a comparatively rare occurrence of the lampbrush fibres in that species.

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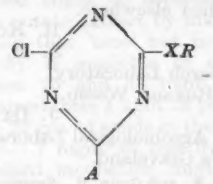
[1] Hsu, T. C., *J. Genet.*, **48**, 311 (1948). Ris, H., *Biol. Bull.*, **89**, 242 (1945). Srivastava, M. D. L., *J. Genet.*, **52**, 480 (1954); *La Cellule*, **52**, 271 (1956).

New s-Triazine Herbicides

In the course of investigations on *s*-triazines, we have discovered a new synthesis of 2-alkoxy- and 2-alkylthio-4,6-dichloro-*s*-triazines. These substances can be obtained by the reaction of an alcohol or a thiol with cyanuric chloride and 2,6 *x* collidine as the acid acceptor. The yield was approximately 80–90 per cent. In a further systematic investigation, we found that in these compounds the chlorine atom can be specifically substituted in good yield by an alkylamino, alkyloxy or alkylthio group.

Compounds with the structure:



in which *X* is —NH—, —O— or —S—, *R* is an alkyl group and *A* is chlorine or *YR*(*Y* may be only —O— or —S—), exhibited strong phytotoxic activity on many plant species (patents applied for).

Illustrative for this action is Fig. 1, which shows the results of spraying chickweed, beet, tomato, oats and beans (from left to right) with 1 per cent solution of 2-pentoxy-4,6-dichloro-*s*-triazine (*TR* 110) in a quantity corresponding to 10 kgm. per hectare. 2-*n*-Butoxy-4,6-dichloro-s-triazine (*TR* 14) and 2-*n*-butylthio-4,6-dichloro-s-triazine (*TR* 35) gave similar results. Fig. 2 shows a control series of pots.

By varying the alkyl group *R*, we found that the triazines with a side-chain of three to six carbon

Fig. 1

Fig. 2

atoms had the highest activity. The herbicidal activity was determined in small field-trials of 1 m.[2]. In this field there were growing lambs' quarters (*Chenopodium album*), chickweed (*Stellaria media*), small nettle (*Urtica urens*) and blue grass (*Poa annua*). The weeds were sprayed with 1 per cent solutions of *TR* 14, *TR* 35, 2-*iso*propylamino-4,6-dichloro-*s*-triazine (*TR* 31) and 2,4-*bis*(diethylamino)-6-chloro-*s*-triazine (Geigy 444 [1-3]), in a quantity corresponding with 10 kgm. per hectare. With this concentration Geigy 444 caused only slight damage to the plant growth. With the other s-triazines mentioned, all the weeds were killed with the exception of blue grass, which recovered after a time.

The new triazines are promising as pre-emergence herbicides. Further extensive field-trials will be attempted. A more detailed account of this work will be published elsewhere.

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[1] Gast, A., Knüsli, E., and Gysin, H., *Experientia*, **11**, 107 (1955).
[2] *Agric. Chemicals*, **10**, 67 (April 1955).
[3] Sweet, R. D., Benedict, C. R., and Crabtree, G., Proc. North-eastern Weed Control Conf. (1956), 182–187; ref. *Chem. Abstr.*, **50**, 10328h (1956).

A New Thiol in Legumes

A new thiol has been found in the red kidney bean, *Phaseolus vulgaris*, and in certain other legumes. The thiol is the principal non-protein thiol of these plants. Glutathione, when present, occurs at much lower concentrations. A provisional name, 'phaseothione', has been assigned to this compound, pending the determination of its chemical structure.

In a survey (unpublished work) of the non-protein thiols in plants, conducted by means of a very sensitive paper chromatographic procedure[1], a major unknown thiol component, 'phaseothione', was detected in extracts of *Ph. vulgaris* leaves. About 1 μmole of phaseothione was present per gram of leaf; lower concentrations were detected in the roots, stems and pods. A trace of glutathione was sometimes identified by precipitation with mercuric nitrate and subsequent chromatography, but the concentration was less than 5 per cent that of phaseothione. The new thiol was also found in the leaves of the lima bean (*Ph. limensis*), the soy bean (*Glycine max*), and white clover (*Trifolium repens*). In the leaves of other legumes, however (*Albizzia julibrissia*, *Arachis hypogea* and *Pisum sativum*), glutathione was found at concentrations typical of leaves generally. No phaseothione was found in these legumes or in twenty-one other species and genera. The results of analyses on several legumes are shown in Table 1.

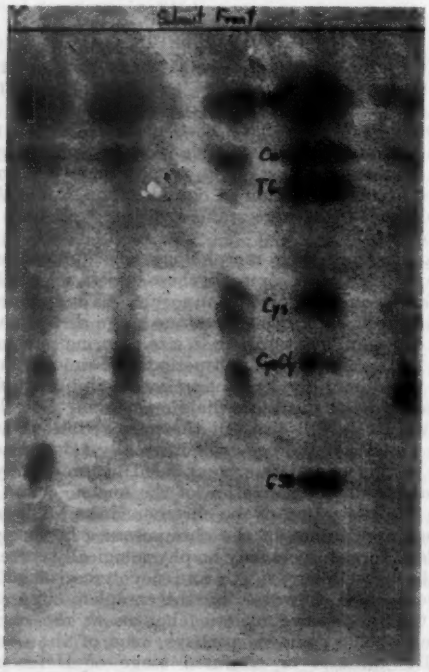
Table 1. Major Non-Protein Thiol Components of Several Legumes

Presence or absence of glutathione was determined by co-chromatography (cf. Fig. 1). Quantities estimated by visual comparison with known amounts of glutathione; quantity of phaseothione estimated by assuming the specific intensity of colour development was identical with that of glutathione. Limit of detection: 0·05 μmole per gm. wet weight

Plant	Estimated quantity of thiol component in μmole/gm. wet weight	
	Glutathione	Phaseothione
Albizzia julibrissia Durazzini (mimosa tree)	0·5	0
Arachis hypogea L. (peanut)	0·5	0
Glycine max (L.) Merr. (soy bean)	0	0·5*
Phaseolus limensis Macfad. (lima bean)	0	0·2
Phaseolus vulgaris L. (red kidney bean)	0	1
Pisum sativum L. (pea)	0·4	0
Trifolium repens L. (white clover)	0	0·5

* Glutathione not detected; interfering substances hindered colour development in region of phaseothione.

Analysis of phaseothione indicated that it contained an amino-acid group, and, as shown in Fig. 1, often



Bean leaf extract plus 5 μmillimoles of GSH | Cysteinyl glycine | Cysteine | 4 μmillimoles markers | Bean leaf extract

Fig. 1. Co-chromatography of bean leaf thiol. Authentic thiols and leaf extract of *Ph. vulgaris* were treated with *N*-(4-hydroxy-1-naphthyl)-*iso*maleimide, chromatographed in *iso*-propanol/*n*-butanol/*N*-acetic acid (75 : 10 : 15), and the thiol components detected with a diazo reagent (ref. 1). HNI, the *iso*maleimide reagent; Cn, an unidentified contaminant (ref. 1) in the reagent; TG, thioglycollate; Cys, cysteine; CysGly, cysteinyl glycine; and GSH, glutathione. The amount of the leaf extract applied to the paper corresponded to 2 mgm. wet weight of tissue

ran with an R_F nearly equal to that of cysteinyl glycine. In *iso*-propanol/*n*-butanol/*N*-acetic acid (45 : 40 : 15 v/v), however, the R_F of phaseothione was 0·66 and that of co-chromatographed cysteinyl-glycine, 0·70. In water-saturated butanol, the R_F values were 0·15 and 0·19, respectively. Phaseothione is apparently not identical with, but may be similar to, cysteinyl glycine. Glutathione, added to bean leaves and extracted, yielded glutathione unchanged on the chromatogram.

Glutathione, determined by the glyoxalase assay, was previously reported[2] in *Ph. vulgaris* hypocotyls at a concentration of 0·4 μmole per gram. Chromatographic analysis of hypocotyl tissue in our hands showed phaseothione at approximately this concentration. Phaseothione, therefore, may be in that class of cysteine-containing thiols with appreciable glyoxalase coenzyme activity[2].

It had been generally assumed that glutathione is ubiquitous in living tissues[4]. Apple fruit constituted the single exception[5]. Since phaseothione may occur in several legumes in place of glutathione, information on the enzymatic functions of the substance, possibly analogous to those of glutathione[6], will be of special interest.

Part of this study was conducted in the laboratory of Prof. A. C. Leopold, Horticulture Department, Purdue University, to whom I am most grateful. Support was provided by a research grant, *C*-2204, from the National Institutes of Health, U.S. Public Health Service, to Prof. Leopold, and by the Milton Fund of Harvard University.

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[1] Price, C. A., and Campbell, C. W., *Biochem. J.* (in the press).
[2] Webster, G. C., *Arch. Biochem. Biophys.*, **47**, 241 (1953).
[3] Wieland, T., Pfleiderer, G., and Lau, H. H., *Biochem. Z.*, **327**, 393 (1956).
[4] Hopkins, F. G., and Morgan, E. J., *Biochem. J.*, **39**, 320 (1945). Synge, R. L. M., in "Modern Methods of Plant Analysis," **4**, 1, edit. by Paech, K., and Tracey, M. V. (Springer-Verlag, Berlin, 1955). Waelsch, H., "Adv. Enzymol.", **13**, 237 (1952).
[5] Schroeder, E. F., and Woodward, G. E., *J. Biol. Chem.*, **129**, 283 (1939).
[6] Racker, E., *Physiol. Rev.*, **35**, 1 (1955). Racker, E., "Glutathione, A Symposium", 165, edit. by Colowick, S., *et al.* (Academic Press, 1954).

Phosphorylase Inhibitor in Potato : Separation from Activator and Possible Relation to Chlorogenic Acid

In a previous study of the factors in ethanolic extracts of potato which influence the activity of potato phosphorylase, it was found that although the observed shortening of the amylose chains synthesized by this enzyme could, in part, be attributed to the presence of inorganic orthophosphate in the extracts, the latter did not cause an inhibition of phosphorylase as measured by the rate of liberation of phosphate from glucose-1-phosphate in the presence of starch primer[1]. However, demonstration of primer (activator) activity of such extracts after de-ionization with ion-exchange resin implied the presence of true inhibitory activity in the extracts. Presumably this inhibitory action is obscured by the presence of activator (primer). Since no inhibitory activity could be demonstrated in the acid or alkaline eluates from cation-exchange columns after chromatography of the potato extracts, it would appear that the inhibitor is acidic. However, attempts to recover inhibitory activity in acid eluates from anion-exchange chromatography of the extracts was complicated by the appearance in these eluates of trace amounts of material, derived from the columns, which in themselves possessed considerable inhibitory activity. In the case of weak phenolformaldehyde resins, the inhibition was traced to the inactivating effect of formaldehyde, whereas polystyrene-quaternary amine resins yielded a green non-fluorescent material devoid of nitrogen which also exhibited inhibitory activity. Pretreatment of the resins under a variety of conditions did not eliminate subsequent elution of inhibitory material.

An alternative route to the separation of activator from inhibitor was afforded by the finding that addition of ethanol to 90 per cent (v/v) at 4° C. to concentrated extracts precipitates most of the activator but not the inhibitor activity. (Further activator activity can be precipitated from aqueous solutions of the inhibitor with ammonium sulphate.) After the removal of the ethanol and tyrosine, which remains undissolved when the supernate from such treatment is dried and taken up in water, further purification of the inhibitor could be achieved by a brief treatment with activated charcoal, followed (after appropriate dilution) by ion-exchange chromatography on 'Dowex-1-acetate' columns by a procedure similar to that developed by Palmer[2]. Upon elution with increasing concentrations of acetic acid, most of the inhibitory activity (determined after vacuum distillation of the acetic acid and neutralization to *p*H 6·0) was found to come through with the eluate fractions between 0·33 *M* and 1 *M* acetic acid.

The inhibitory activity derived from the resin already mentioned could be separated from that derived from the potato extract by taking advantage of the observation that 'true' but not the artefact inhibitory activity is insoluble in absolute ethyl alcohol. Between 25 and 85 mgm. of this final fraction was obtained from 1 kgm. of peeled potatoes, corresponding to 22 gm. of solids in the original crude ethanolic extract. 2 mgm. of this fraction per ml. of enzyme standard incubation mixture[1] inhibited 5 units of phosphorylase to the extent of 66 per cent. (One unit of enzyme will release 1 μequiv. of inorganic phosphate in 30 minutes in 1 ml. of digest containing 11 μequiv. glucose-1-phosphate and 100 μgm. of soluble starch in 0·2 *M* acetate buffer, *p*H 6·0, 37° C.) This purified inhibitor preparation, when neutralized and dried, lost activity and turned brown when stored at room temperature. It contains very little organic phosphorus and nitrogen and is not soluble in acidulated ether and most other organic solvents.

Although the chemical nature of the inhibitor has not been elucidated, the observations described above and the following properties indicate that we may be dealing with a compound or compounds related to chlorogenic acid. Thus the inhibitory activity of preparations obtained from peelings of potatoes is several times that obtained from extracts of peeled potatoes. According to Johnson and Schaal[3], chlorogenic acid is concentrated in the periderm layer of the potato tuber. Preparations derived from peel turn deep orange when treated with acid molybdate ; this reaction has been found to be characteristic for *o*-diphenols but not for monophenols. This was true to a lesser extent of preparations from peeled tubers.

Finally, it has been demonstrated that chlorogenic acid itself is a fairly potent inhibitor of potato phosphorylase. Thus 10^{-3} *M* chlorogenic acid caused 50 per cent inhibition of enzyme activity in a standard

assay system containing 2·4 units of phosphorylase[1]. Apparently most of the inhibition is related to the caffeic acid moiety of chlorogenic acid, inasmuch as the degrees of inhibition obtained under the same conditions in the presence of 0·05 *M* concentrations of acids were as follows: chlorogenic, 93 per cent; caffeic, 85 per cent; quinic, 12 per cent. The mechanism and possible metabolic importance of this inhibition await further investigation.

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[1] Schwimmer, S., and Weston, W. J., *J. Biol. Chem.*, **220**, 143 (1956).
[2] Palmer, J. K., *Connecticut Agric. Exp. Stat. Bull.*, 589 (Feb. 1955).
[3] Johnson G. and Schaal, L. A., *Science*, **115**, 627 (1952).

Germination of Oospores of *Phytophthora erythroseptica*

Germination of comparatively young oospores of *Phytophthora erythroseptica* has been obtained following passage through the digestive tract of the garden snail, *Helix aspersa*. These oospores were produced in oat agar cultures maintained at 20° C. for 4–6 weeks. Portions of the culture were fed to snails, and the excreta collected and kept in a moist atmosphere at room temperature. The old oogonial and antheridial walls appeared unaltered by this treatment, and within a few days germination of a number of oospores was observed.

Oospores germinated by germ tubes, which sometimes terminated in a sporangium, or branched to form more than one sporangium. In many of the germinating spores varying degrees of thinning of the endospore prior to the emergence of the germ tube were observed. Fig. 1 (left) shows a germinated oospore with a partially digested endospore. In several instances, however, germination apparently occurred so rapidly that the germ tube penetrated the thick oospore wall. This can be seen in Fig. 2 (right), in which the constriction of the germ tube throughout the thickness of the wall may be noted.

A similar stimulation of germination has been observed in preliminary experiments with oospores of *Phytophthora cactorum*.

It is well known that snails secrete large amounts of cellulase. Whether the stimulation of germination obtained in these experiments is due to the activity of this enzyme on the oospore wall or to the action of micro-organisms present in the snail intestine is being investigated.

Fig. 1

Fig. 2

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Tsunamis

The term 'tidal wave' is often used for long, high waves which follow a major earth movement or intense atmospheric disturbance affecting the sea. This term is very misleading as the waves are only very rarely connected with tides, and so oceanographers have begun to use the Japanese word 'tsunami' for this phenomenon. It has been suggested, however, that this merely means 'tidal wave' in Japanese so that its use is no more logical.

This view is, however, mistaken; for although the word is used in Japanese in a colloquial sense to describe a tidal wave, the original roots of the word do not have any reference to tides. The word has not always been used in Japanese but has become part of the language in the course of centuries and is spelt by using Chinese characters called Kanji. Japanese words spelt in this way have evolved in rather a curious fashion; the sounds of the words are mainly original to Japanese, but the letters or characters had to be borrowed from the classical Chinese language spoken nearly two thousand years ago. Chinese characters denote short words rather than letters and so each has a definite meaning. On translation to Japanese, these characters can: (1) preserve the same meaning but become associated with a different sound, (2) have a similar sound but now a different meaning, or (3) remain more or less unchanged in sound and meaning. As some words are combinations of these short words, all three types can occur in one word. In the construction of new Japanese words, the last type is generally aimed at; Chinese characters with the appropriate meanings are found and then pronounced after the Chinese manner.

The word 'tsunami' appears to belong mainly to the first type. It consists of the two letters 'tsu' and 'nami'. The part 'tsu' has identical characters with the Chinese 'shin', which can have several meanings but of which only three—a ferry, a harbour, a beach or coast—have any reference to the sea. A survey of place-names suggests, however, that the sound 'tsu' must have been used in ancient Japanese for 'harbour', for there are examples like Tsu (Honshu), Abura-tsu (southern Kyushu) and Naniwa-tsu, which is the old name of a harbour in Osaka Bay. All these places are, or have been, harbours. The sound of the second part of the word, 'nami', has always been used in Japanese for 'waves'; but in Chinese the characters used to indicate the sound would be pronounced 'rou' (or 'lou') or occasionally 'ha', but the meaning is still 'waves'.

The most likely meaning of 'tsunami' is thus a harbour wave, which appears to be a not unreasonable appellation for a 'tidal wave' as these waves affect harbours but not ships at sea. It may be interesting to note that the Japanese for tide or a genuine tidal wave is 'chō-seki'.

J. Darbyshire
S. Ishiguro

National Institute of Oceanography,
Wormley, Nr. Godalming,
Surrey. May 20.

FORTHCOMING EVENTS

Thursday, July 25

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at the Hospital for Tropical Diseases, 4 St. Pancras Way, London, N.W.1), at 7.30 p.m.—Clinical Meeting. Chairman: Brigadier J. S. K. Boyd, O.B.E., F.R.S.

Friday, July 26

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (joint meeting of the FOOD LAW INSTITUTION OF THE UNITED STATES, the SOCIETY FOR ANALYTICAL CHEMISTRY, and the ASSOCIATION OF PUBLIC ANALYSTS, at the Royal Institution, Albemarle Street London, W.1), at 10 a.m. —Conference on "The Control of Chemical Additives in Food".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

OPERATIONAL RESEARCH SCIENTISTS (with a good honours degree in engineering, physics, mathematics or statistics, the ability to handle data, to think objectively and to exercise a high degree of imagination and initiative) IN THE N.C.B.'S FIELD INVESTIGATION GROUP, based in London, to study a wide variety of projects in planning, production and in human problems—The National Coal Board, Staff Department, Hobart House, London, S.W.1, quoting X/756/2/B (July 25).

ADULT LABORATORY STEWARD (with experience in the organization of laboratories, stores or workshops, and preferably some skill with hand tools and model making)—The Principal, Derby and District College of Technology, Normanton Road, Derby (July 27).

ASSISTANT LECTURER (preferably with a special interest in some aspect of social geography) IN GEOGRAPHY—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1 (July 27).

DEMONSTRATOR IN THE DEPARTMENT OF PHYSICAL CHEMISTRY—The Registrar, The University, Leeds 2 (July 31).

HEAD (with good qualifications, administrative ability, and the capacity to further the development of courses in the application of mathematics to industrial problems) OF THE DEPARTMENT OF MATHEMATICS, including Industrial Statistics—The Registrar, College of Technology and Commerce, Leicester (July 27).

SENIOR LECTURER IN ELECTRONICS; a SENIOR LECTURER IN METALLURGY; a LECTURER IN METALLURGY; an ASSISTANT, Grade "B", IN CHEMISTRY; an ASSISTANT, Grade "B", IN BIOLOGY; an ASSISTANT, Grade "B", IN METALLURGY; an ASSISTANT, Grade "B", in MATHEMATICS and a LECTURER IN PHYSICS—The Clerk to the Governing Body, Brunel College of Technology, Woodlands Avenue, Acton Hill, London, W.3 (July 27).

ZOOLOGIST (graduate in zoology of a British university) at the Dove Marine Laboratory—The Registrar, King's College, Newcastle upon Tyne (July 27).

ASSISTANT LECTURER (with a qualification in bacteriology and suitable postgraduate experience) IN BACTERIOLOGY—The Secretary, North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (July 31).

LECTURER IN ORGANIC CHEMISTRY—The Secretary of University Court, The University, Glasgow (July 31).

LECTURER IN THE DEPARTMENT OF ELECTRONICS—The Registrar, The University, Southampton (July 31).

RESEARCH ASSISTANT (with a good honours degree and some post-graduate experience in sedimentary petrology, or palæobotany, or stratigraphical work) IN THE DEPARTMENT OF GEOLOGY, to work under the supervision of Prof. F. W. Cope, on a detailed study of the upper coal measures of North Staffordshire—The Registrar, University College of North Staffordshire, Keele, Staffs (July 31).

DAIRY CHEMIST (with an honours degree in chemistry and preferably experience of dairy chemistry) IN THE DAIRYING DEPARTMENT (at Auchincruive), for investigational work and the supervision of routine analyses—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (August 1).

W. T. HENLEY FELLOW (with a good university degree in electrical engineering or in physics), for research work in electrical engineering—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (August 1).

BIOCHEMIST (male or female, with an appropriate science degree or the A.R.I.C., or other approved qualifications) IN THE PATHOLOGY DEPARTMENT—The Group Secretary, Southport and District H.M.C., Promenade Hospital, Southport (August 3).

CHAIR OF EDUCATION—The Secretary, The University, Exeter (August 3).

PHYSICAL CHEMISTS (with an honours degree or equivalent, and experience in corrosion or a related field) at the Central Electricity Authorities' Research Laboratories, Leatherhead, Surrey, for work on corrosion problems arising in nuclear and conventional power stations —The Director of Establishments, Winsley Street, London, W.1, quoting Ref. N/296 (August 3).

SENIOR LECTURER or ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSICS—The Registrar, The University, Manchester (August 12).

RESEARCH CHEMISTS (2) (with a university honours degree in science with chemistry or organic chemistry as major subjects together with some years of postgraduate research experience) IN THE C.S.I.R.O. WOOL TEXTILE RESEARCH LABORATORIES, Geelong, Victoria, Australia, to carry out investigations on chemical problems associated with the wet-processing of wool—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Ref. No. 462/99 (August 17).

STUDENT for research on the kinetics of gaseous oxidation reactions —The Registrar, The University, Hull (August 17).

JUNIOR LECTURER (young graduate in engineering or physics, interested in heat, light, sound and ventilation) IN THE DEPARTMENT OF APPLIED PHYSIOLOGY—The Dean, London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1 (August 30).

LECTURER (with an honours degree in engineering, an interest in research, and some experience in the fields of nuclear engineering and/or of the compression ignition engine) IN MECHANICAL ENGINEERING—The Registrar, The University, Edgbaston, Birmingham 15 (August 31).

PROFESSOR OF FARM MANAGEMENT; a PROFESSOR OF AGRICULTURAL CHEMISTRY; a PROFESSOR OF CHEMICAL ENGINEERING; and a PROFESSOR OF CELTIC ARCHÆOLOGY—J. P. MacHale, Secretary and Bursar, University College, Dublin (September 15).

ASSISTANT PROFESSOR (preferably graduate with soil science specialization and having PhD. degree or equivalent training) OF SOIL SCIENCE—C. F. Bentley, Department of Soil Science, University of Alberta, Edmonton, Alberta, Canada (October 31).

DIRECTOR OF THE COMMONWEALTH INSTITUTE OF ENTOMOLOGY, London—The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks (October 31).

ANALYTICAL CHEMIST (male or female), for work on gas analysis of hydrocarbon mixtures by physical and classical methods—Prof. H. Ford, Mechanical Engineering Department, Imperial College, London, S.W.7.

ANIMAL ATTENDANT (with previous experience)—The Secretary, Royal Veterinary College, Royal College Street, London, N.W.1.

ASSISTANT EXPERIMENTAL OFFICERS (chemists, physicists, mathematicians, civil and mechanical engineers) AT THE ROAD RESEARCH LABORATORY (D.S.I.R.), Harmondsworth, Middlesex, for varied and interesting work on materials, methods of construction, traffic and safety—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.195/7A.

ASSISTANT EXPERIMENTAL or EXPERIMENTAL OFFICER IN THE MICROBIOLOGY UNIT to work on legumes and root nodule bacteria and/or microbial decomposition of grass leys—The Secretary, The Grassland Research Institute, Hurley, near Maidenhead.

ASSISTANT LECTURER IN ORGANIC CHEMISTRY—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

ASSISTANT LECTURER or LECTURER IN PURE AND/OR APPLIED MATHEMATICS—The Secretary of the Trustees, Magee University College, Londonderry, N. Ireland.

ASSISTANT RECORDIST (education to G.C.E. standard and preferably previous experience in electro-encephalographic recording) IN THE DEPARTMENT OF APPLIED PHYSIOLOGY, Maida Vale Hospital, London, W.9—The Secretary, The National Hospitals for Nervous Diseases, Queen Square, London, W.C.1.

CHEMIST or BIOCHEMIST, Senior Scientific Officer or Scientific Officer grade, to study the uptake and metabolism of radioisotopes by plants, by field and laboratory work—The Group Recruitment Officer (823/34), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

DEPUTY DIRECTOR; and a LECTURER or ASSISTANT LECTURER ON THE STAFF OF THE COMPUTATIONAL UNIT which is about to be set up and will be equipped with a Ferranti Mark II Mercury electronic computer—The Secretary of the Senate, University of London, Senate House, London, W.C.1.

ELECTRICAL ENGINEER (preferably with an honours degree and an elementary knowledge of feedback engineering) IN THE PLANT ENGINEERING DIVISION, for development work having the primary objective of automating steelworks plant—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "E.7".

GEOLOGISTS (with a first- or upper division second-class honours degree in geology) with the Government of British Guiana, for general geological mapping and mineral investigations in the interior of British Guiana—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/30/02.

HEAD (with high academic qualifications in mathematics, with teaching and research or industrial experience) OF THE DEPARTMENT OF MATHEMATICS—The Principal, Technical College, Queen Street South, Huddersfield.

HOSPITAL BIOCHEMIST (with an honours degree, preferably in biochemistry or chemistry), to participate in research into the biochemical aspects of fungal diseases of the skin—The Group Secretary, Huddersfield Hospital Management Committee, The Royal Infirmary, Huddersfield.

JUNIOR LECTURER IN ENTOMOLOGY—The Dean, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

LIBRARIAN (with a working knowledge of at least one foreign language, and preferably experience of scientific literature)—The Secretary, Research Station (University of Bristol), Long Ashton, Bristol.

MINERALOGIST (with a first- or upper division second-class honours degree in geology, with specialization in mineralogy and some experience in X-ray crystallography) IN THE GEOLOGICAL SURVEY DEPARTMENT, Government of Tanganyika, to work chiefly in the GEOLOGICAL SURVEY LABORATORIES on the identification and study of minerals being investigated by the Department—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD. 105/8/04.

PHYSICAL CHEMISTS AND METALLURGISTS, for the study of problems of corrosion of metals in water and steam at elevated temperatures arising from development of new alloys for use in high temperature pressurized water reactors—The Group Recruitment Officer (830/2), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

POST-DOCTORAL RESEARCH FELLOW IN UPPER ATMOSPHERE PHYSICS, for investigations of the spectrum of the aurora and airglow in the PbS region—Dr. A. Vallance Jones, Department of Physics, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

PROFESSOR (NUCLEAR ENGINEER) IN APPLIED SCIENCE, to take charge of a new course for highly selected engineering graduates leading to a Master's degree, to co-ordinate instruction in the several departments, to be responsible for setting up demonstration equipment, such as a subcritical assembly, and to teach the principles of nuclear engineering in at least one department—Dean H. G. Conn, Queen's University, Kingston, Ontario, Canada.

RESEARCH ASSISTANTS (2), for work on the action of gamma radiation on organic compounds and reactions—The Registrar, King's College, Newcastle-upon-Tyne.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Scottish Plant Breeding Station. Report, 1957. Pp. 73+3 plates. (Pentlandfield, Roslin: Scottish Plant Breeding Station, 1957.) [305

Report of the Rugby School Natural History Society for the year 1956. Pp. 32. (Ninetieth Issue.) (Rugby: Rugby School Natural History Society, 1957.) [305

Chemicals in Industry. Pp. viii+76. (West Bromwich: Robinson Brothers, Ltd., 1957.) [305

University of London. University College Annual Report, 1955–1956. Pp. 91. (London: University College, 1957.) [305

Ministry of Education: Science Museum. The International Geophysical Year. By J. Wartnaby. Pp. v+18+8 plates. (London: H.M. Stationery Office, 1957.) 2s. net. [305

Ministry of Education. The Supply and Training of Teachers for Technical Colleges: Report of a Special Committee appointed by the Minister of Education in September, 1956. Pp. xiv+68. (London: H.M. Stationery Office, 1957.) 4s. net. [315

Ministry of Agriculture, Fisheries and Food. Fishery Investigations. Series 2, Vol. 21, No. 3: The Interpretation of Echo Traces. By D. H. Cushing. Pp. iv+16. (London: H.M. Stationery Office, 1957.) 6s. net. [315

William Harvey, 1578–1657—an exhibition of books and manuscripts illustrating his life and work. Pp. 25. (London: Royal College of Physicians, 1957.) [46

Report of the City and Guilds of London Institute for the year 1st October, 1955 to 30th September, 1956. (Seventy-seventh Annual Report.) Pp. v+104. (London: City and Guilds of London Institute, 1957.) [46

Save the National Land Fund: an Appeal to Parliament. Pp. 4. (London: Ramblers' Association, 1957.) [46

Empire Cotton Growing Corporation. Progress Reports from Experiments Stations, Season 1955–56. Nyasaland. Pp. 17. 9*d*. Tanganyika Territory: Eastern Province. Pp. 14. 9*d*. Tanganyika Territory: Lake Province. Pp. 21. 9*d*. (London: Empire Cotton Growing Corporation, 1957.) [46

Universities Council for Adult Education. Report on the year 1955–1956. Pp. 29. (Bristol: W. E. Salt, Dept. of Adult Education, The University, 1957.) [46

World Power Conference. Annual Report, 1956. Pp. 26. (London: World Power Conference, 1957.) [46

Report of the Astronomer Royal to the Board of Visitors of the Royal Greenwich Observatory. Pp. 12. (Herstmonceux: Royal Greenwich Observatory 1957.) [46

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 972, Vol. 250 (6 June 1957): Physico-Chemical Studies of Poly-D-Glutamic Acid from *Bacillus anthracis* Grown *in vitro*. By L. H. Kent, B. R. Record and and R. G. Wallis. Pp. 1–43. (London: Royal Society, 1957.) 13s. 6*d*. [56

University Interchange between the United Kingdom and other European Countries, 1948–1956: a Report on the work of the Committee for Foreign University Interchange. Pp. 56. (London: The British Council, 1957.) [66

Oxford Botanic Garden. Pp. 48. (Oxford: Basil Blackwell, 1957.) 2s. 6*d*. [66

Glossary of Abbreviations for names of Technical, Scientific, Industrial and Professional Organizations, with particular reference to the Telecommunications Industry. Compiled by S. T. Cope. Pp. iv+38. (Chelmsford: Marconi's Wireless Telegraph Co., Ltd., 1957.) 2s. 6*d*. [66

Other Countries

Records of the Queen Victoria Museum, Launceston. New Series, No. 7: Geology of Portion of the Western Tiers. By J. B. A. McKellar. Pp. 13+5 maps. New Series, No. 8: Geology of the Deloraine-Golden Valley Area, Tasmania. By A. T. Wells. Pp. 13+2 maps. (Launceston: Queen Victoria Museum, 1957.) [305

Smithsonian Miscellaneous Collections. Vol. 134, No. 8: Skull of the Bridger Middle Eocene Creodont, Patriofelis Ulta Leidy. By C. Lewis Gazin. Pp. ii+20+4 plates. (Publication 4293.) (Washington, D.C.: Government Printing Office, 1957.) [305

Proceedings of the Irvington House Conference on the Rheumatic Child and His World, Tuesday, November 13, 1956, New York. Pp. 68. (Irvington-on-Hudson, N.Y., and New York City: Irvington House, Research and Treatment Center for Children with Rheumatic Fever and Rheumatic Heart Disease, 1957.) [305

Koninklijk Nederlands Meteorologisch Institut. Middellandse Zee: Oceanografische en Meteorologische Gegevens. (The Mediterranean: Oceanographic and Meteorological Data.) Pp. xix+91 charts. (Publikatienummer: K.N.M.I., 138.) ('S-Gravenhage: Staatsdrukkerij- en Uitgeverijbedrijf, 1957.) 20 florins. [305

World Health Organization. Technical Report Series. No. 118: Accidents in Childhood: Facts as a Basis for Prevention—Report of an Advisory Group. Pp. 40. 1 Swiss franc; 1s. 9*d*.; 0.30 dollars. No. 119: Study Group on Paediatric Education—Report. Pp. 20. 1 Swiss franc; 1s. 9*d*.; 0.30 dollars. (Geneva: World Health Organization; London: H.M. Stationery Office, 1957.) [315

Demographic Yearbook, 1956. (Special Topic: Ethnic and Economic Characteristics.) Eighth Issue. Pp. viii+744. (New York: United Nations; London: H.M. Stationery Office, 1956.) Cloth bound, 8.50 dollars; 60s. Paper bound, 7 dollars; 50s. [315

Science Reports of the Tohoku University, Sendai, Japan. Second Series (Geology). Vol. 28: The Foraminifera from the Adjacent Seas of Japan collected by the S.S. *Soyo-maru*, 1922–1930. Part 3: Planktonic Species. By Kiyoshi Asano. Eocene Diatom Assemblages from the Kellogg and "Sidney" Shales, Mt. Diablo Area, California. By Taro Kanaya. Pp. 124+10 plates. (Sendai: Tohoku University, 1957.) [46

West African Maize Research Unit. Second Annual Report, 1954. Pp. 51. (Ibadan: West African Maize Research Unit; London: Crown Agents for Oversea Governments and Administrations.) 5s. [56

Food and Agriculture Organization of the United Nations. European Commission on Agriculture: Sub-Commission on Agricultural Research. Report on the Uses of Isotopes and Radiation in Agricultural Research, held in Wageningen, Netherlands, 10–14 December 1956. (Meeting Report No. 1956/27.) Pp. ii+39. (Rome: Food and Agriculture Organization of the United Nations, 1957.) [56

State of Illinois: Department of Registration and Education. Natural History Survey Division. Biological Notes, No. 36: A Spectacular Waterfowl Migration Through Central North America. By Frank C. Bellrose. Pp. 24. (Urbana, Ill.: Section of Wildlife Research, Illinois Natural History Survey, 1957.) [56

Yale Peabody Museum of Natural History. Postilla. No. 29 (February 12, 1957): A Redefinition of the Subspecies of *Fodiator acutus*. By James E. Morrow. Pp. 11. No. 30 (February 28, 1957): Notes on the Horned Coot, *Fulica cornuta* Bonaparte. By S. Dillon Ripley. Pp. 8. No. 31 (March 28, 1957): New Birds from the Western Papuan Islands. By S. Dillon Ripley. Pp. 4. (New Haven, Conn.: Yale Peabody Museum of Natural History, 1957.) [66

Power in Uganda 1957–1970: a Study of Economic Growth Prospects for Uganda, with special reference to the Potential Demand for Electricity. Prepared by the Economist Intelligence Unit Limited. Pp. viii+197. (Kampala: Uganda Electricity Board; London: Uganda Electricity Board, 1957.) [76

Checklist of the Coleopterous Insects of Mexico, Central America, The West Indies, and South America, Part 6. (Smithsonian Institution: United States National Museum, Bulletin 185.) Pp. vii+929–1492. (Washington, D.C.: Government Printing Office, 1957.) 2.25 dollars. [116

Proceedings of the Eleventh Meeting of the Animal Husbandry Wing of the Board of Agriculture and Animal Husbandry in India, Ranchi, 28th April to 3rd May 1955. Pp. xi+271. (Delhi: Manager of Publications, 1957.) Rs. 6/12/–; 10s. 6*d*. [116

Second Annual Report of the European Organization for Nuclear Research (CERN), 1956. Pp. vi+71 (19 plates). (Geneva: European Organization for Nuclear Research, 1957.) [116

Indian Forest Bulletin (New Series). Timber Mechanics. No. 201: Studies on Izod Values of Some Indian Timbers. By A. C. Sekhar and D. D. S. Negi. Pp. ii+20. Rs. 1/14/–; 2s. 9*d*. No. 202: Torsional Properties of Some Indian Timbers. By A. C. Sekhar and B. S. Rawat. Pp. ii+14. Rs. 1/2/–; 1s. 9*d*. (Delhi: Manager of Publications, 1957.) [116

United States Naval Observatory. Circular No. 73: Positions, Areas, and Counts of Sunspots, September, 1956. By Winifred Sawtell Cameron. Pp. 11. Circular No. 74: Positions, Areas, and Counts of Sunspots, October, 1956. By Winifred Sawtell Cameron. Pp. 11. (Washington, D.C.: United States Naval Observatory, 1957.) [116

Académie Royal de Belgique. Classe des Sciences. Mémoires. Tome 30, Fascicule 3: Contribution à l'étude de la Diapause chez *Neodiprion sertifer* Geoffr. dans la Nature. Par R. Breny. Pp. 88. (Bruxelles: Académie Royal de Belgique, 1957.) 80 francs. [116

Fisheries Research Board of Canada: Biological Station, St. Andrews, N.B. General Series Circular No. 28 (April, 1957): Recent Oyster Mortalities and a Method for Restoring the Fishery. By R. R. Logie. Pp. 3. General Series Circular No. 29 (April, 1957): Rehabilitation of Disease-Depleted Oyster Fisheries. By H. R. Found and R. R. Logie. Pp. 2. (St. Andrews, N.B.: Fisheries Research Board of Canada, 1957.) [116

United States Department of Agriculture. Technical Bulletin No. 1160: Dent Corn Inbreds and Hybrids Resistant to the Corn Earworm in the South. By W. A. Douglas and R. C. Eckhardt. Pp. 13. (Washington, D.C.: Government Printing Office, 1957.) 10 cents. [116

Académie Royal de Belgique. Annuaire pour 1957 (No. 123). Pp. 426+7 planches. (Bruxelles: Académie Royal de Belgique, 1957.) [116

Transactions and Proceedings of the Geological Society of South Africa. Vol. 59, containing the papers and discussions presented during 1956. Edited by Dr. H. J. Nel. Pp. vi+276+39 plates+ciii. (Johannesburg: Geological Society of South Africa, 1957.) 63s. [116

Aligarh Muslim University Publications. (Zoological Series.) On Indian Insect Types. 5: The Morphology and Life-History of *Leptocorisa varicornis* Fabr. (Coreidae, Hemiptera)—a Pest of Paddy Crop in India. By Dr. S. Shujaatul Akbar. Pp. 1+54+9 plates. (Aligarh: Aligarh Muslim University, 1957.) Rs. 5. [116

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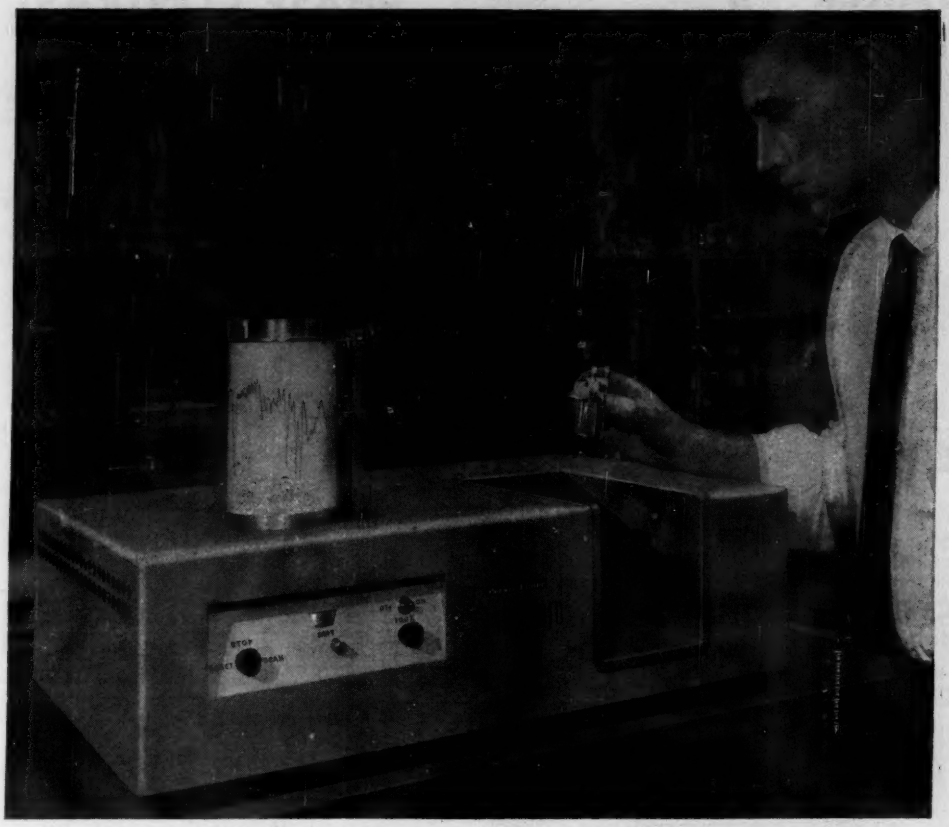

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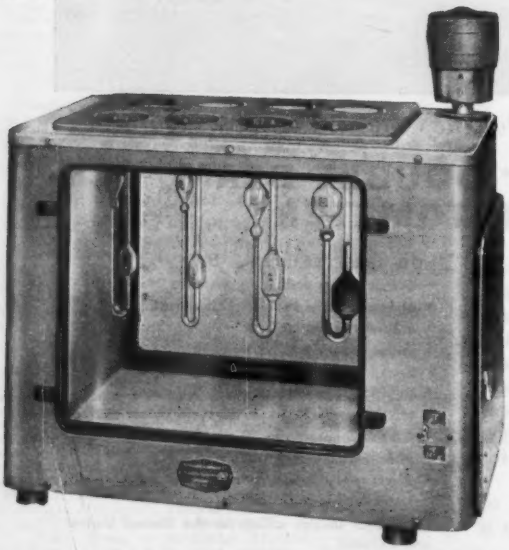

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